ESSENTIAL FISH HABITAT ASSESSMENT REPORT

for the Salmon Fisheries in the

EEZ off the Coast of Alaska

Prepared by

Alaska Department of Fish & Game
National Marine Fisheries Service
North Pacific Fishery Management Council

Compiled by

The Technical Team for Essential Fish Habitat
for the Salmon Fisheries off the Coast of Alaska

With Contributions by

Bill Heard, Jack Helle, K. Koski, Mitch Lorenz, Mike Murphy, Jerry Taylor, and Alex Wertheimer

March 31, 1998

North Pacific Fishery Management Council
605 West 4th Avenue, Suite 306
Anchorage, AK 99501

Essential Fish Habitat Assessment Report
for the
Salmon Fisheries off the Coast of Alaska

Table of Contents

Essential Fish Habitat Assessment Report
Salmon Fisheries off the Coast of Alaska

by
The Technical Team for Essential Fish Habitat
for Salmon Fisheries off the Coast of Alaska

INTRODUCTION

In 1996, the Sustainable Fisheries Act amended the Magnuson-Stevens Fishery Conservation and Management Act to require the description and identification of essential fish habitat (EFH) in fishery management plans (FMPs), adverse impacts on EFH, and actions to conserve and enhance EFH. Guidelines were recently developed by the National Marine Fisheries Service (NMFS) to assist Fishery Management Councils (Councils) in fulfilling the requirements set forth by the Act. In addition, the Act requires consultation between the Secretary and Federal and state agencies on activities that may adversely impact EFH for those species managed under the Act. It also requires the Federal action agency to respond to comments and recommendations made by the Secretary and Councils.

Essential fish habitat means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: “waters” includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; “substrate” includes sediment, hard bottom, structures underlying the waters, and associated biological communities; “necessary” means the habitat required to support a sustainable fishery and a healthy ecosystem; and “spawning, breeding, feeding, or growth to maturity” covers a species’ full life cycle.

After reviewing the best available scientific information, and in cooperation with the Councils, participants in the fishery, interstate commissions, Federal agencies, state agencies, and other interested parties, NMFS will develop written recommendations for the identification of EFH for each FMP. Prior to submitting a written EFH identification recommendation to a Council for an FMP, the draft recommendation will be made available for public review and at least one public meeting will be held. NMFS will work with the affected Council(s) to conduct this review in association with scheduled public Council meetings whenever possible. The review may be conducted at a meeting of the Council committee responsible for habitat issues or as a part of a full Council meeting. After receiving public comment, NMFS will revise its draft recommendations, as appropriate, and forward written recommendation and comments to the Council(s).

The following is a summary of the EFH regulations set forth in the guidelines:

Habitat Requirements by Life History Stage

All FMPs must describe EFH in text and with tables that provide information on the biological requirements for each life history stage of the species. These tables should summarize all available information on environmental and habitat variables that control or limit distribution, abundance, reproduction, growth, survival, and productivity of the managed species. Information in the tables should be supported with citations.

Description and Identification of EFH

An initial inventory of available environmental and fisheries data sources relevant to the managed species should be useful in describing and identifying EFH. This inventory should also help to identify major species-specific habitat data gaps. Deficits in data availability (i.e., accessibility and application of the data) and in data quality (including considerations of scale and resolution; relevance; and potential biases in collection and interpretation) should be identified.

To identify EFH, basic information is needed on current and historic stock size, the geographic range of the managed species, the habitat requirements by life history stage, and the distribution and characteristics of those habitats. Information is also required on the temporal and spatial distribution of each major life history stage (defined by developmental and functional shifts). Since EFH should be identified for each major life history stage, data should be collected on, but not limited to, the distribution, density, growth, mortality, and production of each stage within all habitats occupied, or formerly occupied, by the species. These data should be obtained from the best available information, including peer-reviewed literature, data reports and "gray" literature, data files of government resource agencies, and any other sources of quality information.

The following approach should be used to gather and organize the data necessary for identifying EFH. Information from all levels should be used to identify EFH. The goal of this procedure is to include as many levels of analysis as possible within the constraints of the available data. Councils should strive to obtain data sufficient to describe habitat at the highest level of detail (i.e., Level 4).

(1) Level 1: Presence/absence distribution data are available for some or all portions of the geographic range of the species. At this level, only presence/absence data are available to describe the distribution of a species (or life history stage) in relation to potential habitats. Care should be taken to ensure that all potential habitats have been sampled adequately. In the event that distribution data are available for only portions of the geographic area occupied by a particular life history stage of a species, EFH can be inferred on the basis of distributions among habitats where the species has been found and on information about its habitat requirements and behavior.

(2) Level 2: Habitat-related densities of the species are available. At this level, quantitative data (i.e., density or relative abundance) are available for the habitats occupied by a species or life history stage. Because the efficiency of sampling methods is often affected by habitat characteristics, strict quality assurance criteria should be used to ensure that density estimates are comparable among methods and habitats. Density data should reflect habitat utilization, and the degree that a habitat is utilized is assumed to be indicative of habitat value. When assessing habitat value on the basis of fish densities in this manner, temporal changes in habitat availability and utilization should be considered.

(3) Level 3: Growth, reproduction, or survival rates within habitats are available. At this level, data are available on habitat-related growth, reproduction, and/or survival by life history stage. The habitats contributing the most to productivity should be those that support the highest growth, reproduction, and survival of the species (or life history stage).

(4) Level 4: Production rates by habitat are available. At this level, data are available that directly relate the production rates of a species or life history stage to habitat type, quantity, quality, and location. Essential habitats are those necessary to maintain fish production consistent with a sustainable fishery and the managed species' contribution to a healthy ecosystem.

The information obtained through the analysis of this section will allow Councils to assess the relative value of habitats. Councils should interpret this information in a risk-averse fashion, to ensure adequate areas are protected as EFH of managed species. Level 1 information, if available, should be used to identify the geographic range of the species. Level 2 through 4 information, if available, should be used to identify the habitats valued most highly within the geographic range of the species. If only Level 1 information is available, presence/absence data should be evaluated (e.g., using a frequency of occurrence or other appropriate analysis) to identify those habitat areas most commonly used by the species. Areas so identified should be considered essential for the species. However, habitats of intermediate and low value may also be essential, depending on the health of the fish population and the ecosystem. Councils must demonstrate that the best scientific information available was used in the identification of EFH, consistent with National Standard 2, but other data may also be used for the identification. If a species is overfished, and habitat loss or degradation may be contributing to the species being identified as overfished, all habitats currently used by the species should be considered essential in addition to certain historic habitats that are necessary to support rebuilding the fishery and for which restoration is technologically and economically feasible. Once the fishery is no longer considered overfished, the EFH identification should be reviewed, and the FMP amended, if appropriate. EFH will always be greater than or equal to aquatic areas that have been identified as "critical habitat" for any managed species listed as threatened or endangered under the Endangered Species Act. Where a stock of a species is considered to be healthy, then EFH for the species should be a subset of all existing habitat for the species.

Ecological relationships among species and between the species and their habitat require, where possible, that an ecosystem approach be used in determining the EFH of a managed species or species assemblage. The extent of the EFH should be based on the judgment of the Secretary and the appropriate Council(s) regarding the quantity and quality of habitat that is necessary to maintain a sustainable fishery and the managed species' contribution to a healthy ecosystem. If degraded or inaccessible aquatic habitat has contributed to the reduced yields of a species or assemblage, and in the judgment of the Secretary and the appropriate Council(s), the degraded conditions can be reversed through such actions as improved fish passage techniques (for fish blockages), improved water quality or quantity measures (removal of contaminants or increasing flows), and similar measures that are technologically and economically feasible, then EFH should include those habitats that would be essential to the species to obtain increased yields.

The general distribution and geographic limits of EFH for each life history stage should be presented in FMPs in the form of maps. Ultimately, these data should be incorporated into a geographic information system (GIS) to facilitate analysis and presentation. These maps may be presented as fixed in time and space, but they should encompass all appropriate temporal and spatial variability in the distribution of EFH. If the geographic boundaries of EFH change seasonally, annually, or decadally, these changing distributions need to be represented in the maps. Different types of EFH should be identified on maps along with areas used by different life history stages of the species. The type of information used to identify EFH should be included in map legends, and more detailed and informative maps should be produced as more complete information about population responses (e.g., growth, survival, or reproductive rates) to habitat characteristics becomes available. Where the present distribution or stock size of a species or life history stage is different from the historical distribution or stock size, then maps of historical habitat boundaries should be included in the FMP, if known. The EFH maps are a means to visually present the EFH described in the FMP. If the maps identifying EFH and the information in the description of EFH differ, the description is ultimately determinative of the limits of EFH.

Prey species

Loss of prey is an adverse effect on EFH and a managed species, because one component of EFH is that it be necessary for feeding. Therefore, actions that reduce the availability of a major prey species, either through direct harm or capture, or through adverse impacts to the prey species' habitat that are known to cause a reduction in the population of the prey species may be considered adverse effects on a managed species and its EFH. FMPs should identify the major prey species for the species in the FMU and generally describe the location of prey species' habitat. Actions that cause a reduction of the prey species population, including where there exists evidence that adverse effects to habitat of prey species is causing a decline in the availability of the prey species, should also be described and identified. Adverse effects on prey species and their habitats may result from fishing and non-fishing activities.

Identification of habitat areas of particular concern

FMPs should identify habitat areas of particular concern within EFH. In determining whether a type, or area of EFH is a habitat area of particular concern, one or more of the following criteria must be met:

(i) The importance of the ecological function provided by the habitat.
(ii) The extent to which the habitat is sensitive to human-induced environmental degradation.
(iii) Whether, and to what extent, development activities are, or will be, stressing the habitat type.
(iv) The rarity of the habitat type.

TECHNICAL TEAM REPORT

Because the salmon FMP regulates fisheries in the waters off the entire coast of Alaska and bans net fishing, with exceptions, for salmon off the coast in the EEZ, and also defines management measures for salmon troll fisheries in Southeast Alaska EEZ waters, all water bodies used by anadromous salmon throughout Alaska must be considered for EFH identification. Although much of the salmon troll fishery in SE Alaska occurs within State jurisdictional waters, significant parts of the fishery do occur within the EEZ. As a practical matter, the NPFMC and State of Alaska have effectively implemented this FMP under a joint agreement whereby State fishery regulations also apply within the EEZ. This management deferral by NPFMC to State fishery regulations, however, does not exempt the NPFMC from mandatory requirements to implement EFH provisions of the Magnuson-Stevens Fishery Conservation and Management Act.

Essential Fish Habitat for the salmon fisheries off the coast of Alaska consists of the aquatic habitat, both freshwater and marine, necessary to allow for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to healthy ecosystems. In addition to providing a sustainable fishery, salmon are important “keystone” species that are fundamental to the integrity and health of their ecosystems. Salmon returning from the sea to spawn transport basic nutrients that support the productivity of stream and lake ecosystems, and the salmon themselves provide essential food for numerous consumer species. Loss of these functions would cause a long-term reduction in ecosystem productivity and reduced population viability for dependent species.

As required by regulations, EFH needs to be defined for different stages of the salmon life history. Six life stages were recognized, based on major differences in distribution and habitat requirements. These were (1) eggs and larvae, (2) juveniles in fresh water, (3) juveniles in the estuary, (4) juveniles before their first winter in the marine environment, (5) immature and maturing adults in the marine environment, and (6) adults in fresh water. Habitat requirements within these periods can differ significantly (e.g., juveniles in freshwater require different habitats for summer rearing, winter rearing, and downstream migration). The six major life stages used in this assessment, however, are defined at a geographic scale appropriate for EFH determinations.

As a first step in identifying and describing EFH for Salmon Fisheries off the Coast of Alaska, the Team summarized the available relevant information on the five species of salmon covered in the NPFMC salmon FMP (attached). Salmon have been studied for many years, and as a result, much is known about their distribution, life histories, and habitat requirements. Relationships between salmon productivity and habitat quantity and quality are generally known, and population bottlenecks have been identified for most life stages. In some cases, quantitative models are available for predicting salmon abundance and production as a function of quantity and quality of habitat. Most of this knowledge, however, is in the form of scientific generalizations that can only be applied if the necessary site-specific habitat information is available.

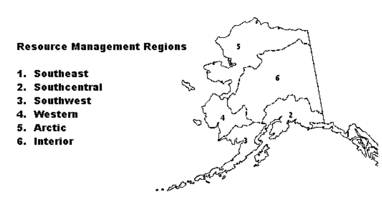

Figure 1. Regional boundaries of the Resource Management Regions established by the Joint Boards of Fisheries and Game.

Because habitat and fish information is lacking for some Alaska watersheds, the Team elected to designate an additional level of information for identifying EFH. A “Level 0" was deemed necessary to accommodate conditions where no systematic sampling has been conducted for the species and life stage in parts of the known geographic range. They may have been caught opportunistically in small numbers during research or other activities. This condition applies to some water bodies in the Western, Arctic, and Interior Regions of Alaska (Figure 1) where limited survey work has been done.

The level of available information for identifying EFH ranges from Level 0 in regions that have not been systematically surveyed to Level 4 in particular watersheds and landscapes that have been studied intensively. Where direct observations are lacking, the distribution of various life stages could sometimes be inferred from correlated data. In this assessment, for example, the distribution of eggs and larvae was inferred from the distribution of spawning adults. Distribution of juveniles in fresh water, however, can not be inferred this way because rearing areas are often different from spawning areas.

For the purpose of identifying EFH, the distribution of salmon in a watershed can be assumed based on access to salt water, with the upstream limits determined by presence of migration blockages, such as waterfalls and stream segments with steep gradient. According to the Alaska Forest Resources and Practices Act (AS 41.17), an "anadromous water body" means the portion of a fresh water body or estuarine area that (A) is cataloged under AS 16.05.870 as important for anadromous fish; or (B) has been determined by ADF&G to contain or exhibit evidence of anadromous fish, in which case the anadromous portion of the stream or waterway extends up to the first point of physical blockage (Table 1). Therefore, if salmon occur in a stream's estuary, the area of stream up to the first point of physical blockage as defined in Table 1 is presumed to be salmon habitat.

Information levels of EFH assessments currently available for Alaska salmon by regions.

Region I, Southeastern

Species	Eggs and larvae	Juveniles fresh water (fry - smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults, fresh water
Chinook	1-2	1-2	1-2	1-2	1-2	1-3
Coho	1-3*	2-4*	1-2	1	1	1-3
Pink	1-3	1-3	1-3	1-3	1-3	1-3
Sockeye	1-3	1-4*	1-3	1-2	1-2	1-3
Chum	1-3	1-3	1-3	1-3	1-2	1-3

Region II, Southcentral

Species	Eggs and larvae	Juveniles fresh water (fry - smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults fresh water
Chinook	1-2	1-3	1	1	1-2	1-3
Coho	1-2	1-2	1-2	1	1-2	1-2
Pink	1-3	1-2	1-2	1-3	1-3	1-3
Sockeye	1-3	1-4	1-2	1	1-2	1-3
Chum	1-3	1-3	1-2	1-3	1-2	1-3

Region III, Southwestern

Species	Eggs and larvae	Juveniles fresh water (fry-smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults fresh water
Chinook	1-2	1-2	1	1	1-2	1-3
Coho	1-2	1-2	1-2	1	1-2	1-2
Pink	1-2	1-2	1-2	1-2	1-2	1-3
Sockeye	1-3	1-4	1-2	1-2	1-2	1-3
Chum	1-3	1-2	1-2	1-2	1-2	1-3

* Level 3-4 knowledge is available for some stream systems that have been intensively studied, such as the Situk River.

Information Sources

A significant body of information exists on the life histories and general distribution of salmon in Alaska. The location of many freshwater water bodies used by salmon are contained in documents organized and maintained by the ADF&G. Alaska Statute 16.05.870 requires ADF&G to specify the various streams that are important for spawning, rearing, or migration of anadromous fishes. This is accomplished through the *Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fishes* and the *Atlas to the Catalog of Waters Important for Spawning, Returning or Migration of Anadromous Fishes*. The Catalog lists water bodies documented to be used by anadromous fish. The Atlas shows locations of these waters and the species and life stages that use them. The Catalog and Atlas are divided into six volumes for the six resource management regions established in 1982 by the Joint Boards of Fisheries and Game.

Information levels of EFH assessments currenlty available for Alaska salmon by regions.

Region IV, Western

Species	Eggs and larvae	Juveniles fresh water (fry - smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults, fresh water
Chinook	1-2	1	1	1	1-2	1-2
Coho	1-2	1	1	1	1	1-2
Pink	1	1	1	1	1	1
Sockeye	1	1	0a	0a	1-2	1
Chum	1-2	0a	0a	0a	1-2	1-2

Region V, Arctic

Species	Eggs and larvae	Juveniles fresh water (fry - smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults fresh water
Chinook	1	1	1	1	1	1
Coho	1	1	1	0a	1	1
Pink	1	0a	0a	0a	0a	1
Sockeye	1	1	0a	0a	0a	1
Chum	1	0a	0a	0a	0a	1-2

Region VI, Interior

Species	Eggs and larvae	Juveniles fresh water (fry-smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults fresh water
Chinook	1	1	1	1	1	1
Coho	1	1	1	1	1	1
Pink	1	0a	0a	1	0a	1
Sockeye	1	1	0a	0a	0a	1
Chum	1-2	1	1	1	1	1-2

0a: Some information on a species' life stage upon which to infer general distribution

The Catalog and Atlas, however, have significant limitations. The location information and maps are derived from U.S. Geological Survey quadrangles which may be out of date because of changes in channel and coastline configurations. In Southeast Alaska, for example, new streams are colonized by salmon in Glacier Bay as glaciers rapidly recede. Polygons are sometimes used to specify areas with a number of salmon streams that could not be depicted legibly on the maps. Waters within these polygons are often productive for juvenile salmon.

Data for the Catalog come from surveys by aircraft, boat, and foot for purposes of managing fish habitat and fisheries, and the upper limit of salmon is not always observed. Upper points specified in the Catalog usually reflect the extent of surveys or known fish usage rather than actual limits of anadromous fish.

In addition, only a limited number of water bodies have actually been surveyed. Virtually all coastal waters in the State provide important habitat for anadromous fish, as do many unsurveyed small- and medium-sized tributaries to known anadromous fish-bearing water bodies in remote parts of the State. Small tributaries, flood channels, intermittent streams and beaver ponds are often used for rearing. Because of their remote location, small size, or ephemeral nature, most of these systems have not been surveyed and are not included in the Catalog or Atlas. Because of their importance in some life stages of some salmon species, these areas fall under the framework of EFH.

A good source of habitat information for Southeast Alaska is a Geographical Information System maintained by the USDA Forest Service. This GIS has a "streams layer" for the Tongass National Forest which classifies streams by fish species present and physical attributes (channel type). For coho salmon, the Forest Service has a model that predicts coho salmon smolt production by channel type. Entire watersheds can be modeled to predict smolt yield. The "streams layer" is continuously updated as new information on location and fish species presence is discovered.

Table 1. Criteria for determining the upstream limit of salmon in a stream system. The area downstream of the lowermost migration barrier on a stream is presumed to be salmon habitat where ADF&G has determined that the stream or estuary contains the species. This table was developed by the Department of Fish and Game and Department of Natural Resources as a revision to the Alaska Forest Resources and Practices Act (AS 41.17.950).

Criterion	**Species**				
	Chinook	Coho	Sockeye	Chum	Pink
Max Fall Height. A blockage may be presumed if fall height exceeds:	3.3 m	3.3 m	3.0 m	1.2 m with deep jump pool; 0.9 m without pool	
Pool depth. A blockage may be presumed if the unobstructed water column depth within the pool is less than:	1.25 times fall height, except that there is no minimum pool depth for falls <1.2 m for coho and <0.6 m for other species.				
Steep channel. A blockage may be presumed at the upper end of the reach if channel steepness exceeds the following without resting places for fish:	>70 m @ 12% gradient >30 m @ 16% gradient >15 m @ 20% gradient >8 m @ 24% gradient			>30 m @ 9% gradient	

<u>References</u>

Alaska Department of Fish and Game. 1997. An atlas to the catalog of waters important for spawning, rearing, or migration of anadromous fishes. ADF&G, Habitat and Restoration Division, 333 Raspberry Road, Anchorage, AK. 99518-1599 .

Alaska Department of Fish and Game (ADF&G). 1986. Alaska habitat management guide; guidelines for the protection of fish and their habitat. ADF&G, Habitat Division, 142 p. Juneau, AK 99801

Groot, C., and L. Margolis. (eds.) 1991. Pacific salmon life histories. Univ. British Columbia Press.
Gustafson, R. G., T. C. Wainwright, G. A. Winans, F. W. Waknitz, L. T. Parker, and R.S. Waples. 1997. Status review of sockeye salmon from Washington and Oregon. NOAA Tech. Memo. NMFS-NWFSC-33. NMFS, 2725 Montlake Blvd. E., Seattle, WA 98112-2097
Halupka, K.C., M. F. Wilson, M. D. Bryant, F. H. Everest and A. J. Gharrett. in press. Intraspecific diversity of Pacific salmon in Southeast Alaska. Forestry Sci. Lab., Pacific Northwest Research Station, USDA. 2770 Sherwood Lane, Suite 2A Juneau, AK 99801-8545
Hard, J. J., R. G. Kope, W. S. Grant, F. W. Waknitz, L. T. Parker, and R. S. Waples. 1996. Status review of pink salmon from Washington, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-25. NMFS, 2725 Montlake Blvd. E., Seattle, WA 98112-2097
Johnson, O. W., W. S. Grant, R. G. Kope, K. Neely, F. W. Waknitz, and R. S. Waples 1997. Status review of chum salmon from Washington, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-32. NMFS, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.
Myers, K.W., K. Y. Aydin, R. V. Walker, S. Fowler, and M. L. Dalhberg. 1996. Known ocean ranges of stocks of Pacific salmon and steelhead as shown by tagging experiments, 1956-1995. (NPAFC Doc. 192.) FRI-UW-9614. Univ. Wash., Fisheries Research Institute, Box 357980, Seattle, WA 98195-7980.
USDA Forest Service, Geographic Information System, Streams Layer. U.S. Forest Service, Juneau, AK 99801.
Weitkamp, L. A., T. W. Wainwright, G. J. Bryant, G. B. Miller, D. J. Teel, R. G. Kope, and R. S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-24. NMFS, 2725 Montlake Blvd. E., Seattle, WA 98112-2097
Wertheimer, W.C. 1996. The status of Alaska salmon. Pages 179-197 *In* J. D. Stroder, P. A. Bisson, and R. J. Naiman (eds.). Pacific salmon and their ecosystems: status and future options. Symposium Proc., Seattle, WA., Jan. 10-12, 1994. Chapman Hall, NY.

SUMMARY OF TECHNICAL TEAM RECOMMENDATIONS

Salmon EFH is the aquatic habitat, both freshwater and marine, necessary to allow for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to healthy ecosystems.

Freshwater EFH for the salmon fisheries in Alaska includes all streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon in the State.
This represents a vast array of diverse aquatic habitats over an extremely large geographic area. Alaska contains over 3,000 rivers and has over 3 million lakes > 8 ha. Over 14,000 water bodies containing anadromous salmonids identified in the State represent only part of the salmon EFH in Alaska because many likely habitats have not been surveyed. In addition to current and historically accessible waters used by Alaska salmon, other potential spawning and rearing habitats exist beyond the limits of upstream migration due to barrier falls or steep-gradient rapids. Salmon access to existing or potential habitats can change over time due to many factors, including glacial advance or recession, post-glacial rebound, and tectonic subsidence or uplifting of streams in earthquakes.

Marine EFH for the salmon fisheries in Alaska include all estuarine and marine areas utilized by Pacific salmon of Alaska origin, extending from the influence of tidewater and tidally submerged habitats to the limits of the U.S. EEZ.
This habitat includes waters of the Continental Shelf, which extends to about 30-100 km offshore from Dixon Entrance to Kodiak Island, then becomes more narrow along the Pacific Ocean side of the Alaska Peninsula and Aleutian Islands chain. In Bering Sea areas of Southwest and Western Alaska and in Chukchi and Beaufort Seas areas of Northwest and Northern Alaska, the Continental Shelf becomes much wider. In oceanic waters beyond the Continental Shelf, the documented range of Alaska salmon extends from 42° N latitude north to the Arctic Ocean and to 160° E longitude. In the deeper waters of the Continental Slope and ocean basin, salmon occupy the upper water column, generally from the surface to a depth of about 50 m. Chinook and chum salmon, however, use deeper layers, generally to about 300 m, but on occasion to 500 m. The range of EFH for salmon is the subset of this habitat that occurs within the 320 km EEZ boundary of the United States. Foreign waters (i.e., off British Columbia in the Gulf of Alaska and off Russia in the Bering Sea) and international waters are not included in salmon EFH because they are outside U.S. jurisdiction. The marine EFH for Alaska salmon fisheries described above is also EFH for the Pacific coast salmon fishery for those salmon stocks of Pacific Northwest origin that migrate through Canadian waters into the Alaska EFH zone.

By the proposed rule, because most salmon stocks in Alaska are currently healthy, EFH should be identified as a subset of all existing habitats for the species. Nevertheless, the Technical Team recommends that all habitats within the jurisdictional boundaries of Alaska that are accessible to salmon be identified as EFH for salmon. All of this habitat contributes to production at some level. Although production from individual habitat areas may be small, collectively even small contributions help to sustain salmon fisheries at current levels. Fisheries for coho and pink salmon, for example, depend on the cumulative production from thousands of small streams that are widely distributed across coastal Alaska. To maintain the present healthy status of the ecosystem and fisheries, it must be recognized that any incremental loss of available habitat will result in less-healthy stocks with reduced fishery potential. Policies that accept reductions in Alaska salmon EFH by designating less-essential subsets of existing habitats could cause unacceptable reductions in salmon contributions to fisheries and ecosystems. It is appropriate, therefore, that all salmon habitats in Alaska fresh waters be identified as EFH.

In the marine environment, Pacific salmon range throughout the Gulf of Alaska, North Pacific Ocean, and Bering Sea. Virtually all marine waters adjacent to Alaska, from nearshore and coastal areas to the limits of the U.S. EEZ, are utilized by salmon. Large-scale research programs, such as GLOBEC and OCC, currently are addressing the concern that ocean carrying capacity for salmon is limited, and density-dependent restrictions on growth or survival may be occurring at current levels of abundance. If density-dependent interactions are already evident, any reduction or degradation of marine habitats of salmon will result in incremental loss in productivity. Thus at this time, all existing marine habitat is essential to maintain current levels of abundance and productivity of salmon in Alaska.

From a science perspective, no rationale exists to identify a subset of existing habitat as non-essential for maintaining healthy salmon production levels. There is, however, substantial rationale to justify an inclusive definition of EFH. Even when habitats remain stable, salmon populations may fluctuate significantly due to factors such as weather, climate, and changes in predator or prey abundance. Salmon use a broader range of freshwater habitat during periods of high abundance. Habitat productivity also varies along with natural long-term disturbance regimes, so that a particular watershed may have low productivity after an event such as a major flood, followed by a period of higher, more stable productivity. Locations of salmon concentrations in freshwater, estuarine, and marine habitats may change unpredictably, so that current areas of known concentration would not adequately cover required habitat. Regime shifts in ocean conditions also cyclically affect salmon distribution and survival. Designating only that habitat with current high abundance or productivity as EFH ignores the implications of such short- and long-term cycles. The broad range and diversity of salmon habitats must be conserved to provide for periods of abundance, as well as to avoid severely reduced production during poor years.

The recommended definition of salmon EFH is most consistent with existing Federal and State laws and policies that protect anadromous fish and their habitat, such as Alaska Statute Title 16, the Alaska Forest Resources and Practices Act, the National Forest Management Act, the Tongass Land Management Plan, the Clean Water Act, and the Coastal Zone Management Act. These laws and policies conserve anadromous fish habitat and do not exempt portions of it based on relative productivity.

Even with the inclusive definition of EFH recommended here, significant portions of salmon habitat would not be designated as EFH because they are outside U.S. jurisdiction. Examples of specific habitat areas that are not considered EFH for Alaska salmon are 1) Canadian parts of the transboundary rivers, including the upper Yukon River where major chinook and chum salmon production contributes to Alaska fisheries; and 2) international waters outside the EEZ.

Based on the foregoing information and attached descriptions of essential habitat for chinook, coho, pink, chum, and sockeye salmon, the following specific definitions of EFH are proposed, by species and life stage, for the salmon fisheries in Alaska. Maps showing the extent of recommended EFH are provided only for immature and maturing adult salmon in marine habitats. These maps show the general distribution and areas of known concentration. The concept of “areas of known concentration” as used for marine EFH does not apply to salmon in fresh water because various habitats for spawning, rearing, and migration are distributed on a finer scale (reach level) within watersheds. The general distributions of salmon in fresh water includes virtually all the coastal streams to about 70° N latitude. Maps of documented salmon occurrence in fresh water (representing only a subset of salmon EFH) can be found in the ADF&G stream Atlas.

See table of contents for the following charts:

Known Life History Traits

Habitat Associations

Reproductive Traits

Habitat Description for Pink salmon
(Oncorhynchus gorbuscha)

Management Plan and area(s) Salmon Fisheries in the EEZ Off the Coast of Alaska, NPFMC, 1990

Life History and General Distribution

The natural freshwater range of pink salmon includes the Pacific rim of Asia and North America north of about 40°N. Within this vast area, spawning pink salmon are widely distributed in coastal streams of both continents up to the Bering Strait. North, east and west of the Bering Strait, spawning populations become more irregular and occasional. Centers of large spawning populations occur at roughly parallel positions along the two continents from about latitudes 44°N to 65°N in Asia and about 48°N to 64°N in North America. In marine environments along both the Asian and North American coastlines pink salmon occupy ocean waters south of the limits of spawning streams.

Pink salmon are distinguished from other Pacific salmon by having a fixed two-year life span, being the smallest of the Pacific salmon as adults (averaging 1.0-2.5 kg), the fact that the young migrate to sea soon after emerging from the gravel, and developing a marked hump in large maturing males. This last characteristic is responsible for the vernacular name humpback salmon used in some areas. Because of the fixed two-year life cycle, pink salmon spawning in a particular river system in old and even years are reproductively isolated from each other and have developed into genetically different lines. In some river systems, like the Fraser River in British Columbia, only the odd-year line exists; returns in even years are negligible. In Bristol Bay, Alaska, the major runs occur in even years, whereas the coastal area between these two river systems is characterized by runs in both even and odd years. In different parts of the range populations are sometimes characterized by the phenomena of dominance where one brood line is much stronger than the other brood line. Upon emergence, pink salmon fry migrate quickly to sea and grow rapidly as they make extensive feeding migrations. After eighteen months in the ocean the maturing fish return to their river of origin to spawn and die.

Pink salmon are considered to be have either the simplest or most specialized life cycle within the genus, depending on whether Pacific salmon originated from marine or freshwater ancestors. One view holds that *Oncorhynchus* evolved from an ancestral freshwater form of Pacific *Salmo* during the Pleistocene, probably in the vicinity of the present-day Sea of Japan. Under this scenario, pink salmon that rely least on the freshwater environment are the most specialized. Pink salmon have 52 chromosomes, fewer than other Pacific salmon, which also may suggest specialization. Another view considers Salmonidae as relatively primitive teleosts, of probable marine pelagic origin, and about five million years old. This alternative view to freshwater origin of Pacific salmon is supported, in part, by Pliocene fossils from California and Oregon. The marine origin view holds that during evolution salmonids tended towards greater dependence on fresh water and away from dependence on the sea. Under this scenario, pink salmon, with the least dependence on the freshwater environment, is considered the least advanced extant *Oncorhynchus* species.

Fisheries

Pink salmon are the most abundant Pacific salmon, contributing about 40% by weight and 60% in numbers of all salmon caught commercially in the North Pacific Ocean and adjacent waters. Coastal fisheries for pink salmon presently occur in Asian (Japan and Russia) and North America (Canada and the United States) with major fisheries in both Russia and the U.S. Historically some pink salmon were caught in high seas fisheries by Japan and Russia. Most pink salmon in the U.S. are caught in Alaska where major fisheries occur in Southeast, Prince William Sound, and Kodiak regions. Lessor fisheries for pink salmon occur in Cook Inlet, Alaska Peninsula and Bristol Bay regions. Alaska fisheries for pink salmon occur primarily within State of Alaska territorial seas (inside 3-miles).

Pink salmon catches have been at historic records in Alaska over the past decade with catches exceeding 100 million fish in several years. Most pink salmon in Alaska are caught by purse seines with smaller commercial catches made by set and drift gill net and troll fisheries. Recreational fisheries in Alaska usually harvest between 200 and 400 thousand pink salmon annually. Historically, pink salmon in Alaska have been harvested, on average, at between 60% and 75% of the total annual run.

Purse seine fisheries for pink salmon have some bycatch associated with them, primarily other salmon. The most important bycatch issue is in the Southeastern region where younger marine-age chinook salmon, similar in size to adult pink salmon, are caught in pink salmon purse seine fisheries. The total harvest of chinook salmon in this region is controlled by quotas under auspices of the Pacific Salmon Treaty. The Alaska Board of Fisheries allocates a portion of the quota for chinook salmon as an allowable bycatch in purse seine fisheries targeted on pink salmon.

Measured marine survivals of pink salmon, from entry of fry into stream mouth estuaries to returning adults, have ranged from 0.2% to over 20%. Scientist, in general, believe that much of the natural mortality of pink salmon in the marine environment occurs within the first few months before advanced juveniles move offshore into more pelagic ocean waters. Pink salmon populations can be very resilient, rebounding from weak to strong run strength in regional stock groups within one or two generations.

Relevant Trophic Information

Pink salmon eggs, alevins, and fry in freshwater streams provide an important nutrient input and food source for aquatic invertebrates, other fishes, birds and small mammals. In the marine environment, pink salmon fry and juveniles are food for a host of other fishes and coastal sea birds.

Subadult and adult pink salmon are known to be eaten by fifteen different marine mammals, sharks, other fishes such as Pacific halibut, and humpback whales. Because pink salmon are the most abundant salmon in the North Pacific, it is likely they comprise a significant portion of the salmonids eaten by marine mammals.

Millions of pink salmon adults returning to spawn in thousands of streams through out Alaska provide significant nutrient input into the trophic level of these coastal watersheds. Adult pink salmon in streams are major food sources for gulls, eagles, and other birds, along with bear, otter, mink and other mammals.

Describe any potential gear impacts on the habitats of this or other species.

Because pink salmon are primarily caught in purse seines there are no known gear impacts to the marine habitats where these fisheries occur.

What is the approximate upper size limit of juvenile fish (in cm)? Roughly 25 cm.

Provide source (agency, name and phone number or literature reference for any possible additional distribution data.

Karl Hofmeister, Alaska Department of Fish and Game, 907-465-4250
Chris Kondzela, NMFS, Auke Bay Laboratory, 907-789-6084

Habitat and Biological Associations (if known) Narrative

Eggs and Spawning: Pink salmon choose a fairly uniform spawning bed in small and large streams in both Asia and North America. Generally, these spawning beds are situated on riffles with clean gravel, or along the borders between pools and riffles in shallow water with moderate to fast currents. In large rivers, they may spawn in discrete sections of main channels or in tributary channels. Pink salmon avoid spawning in quiet deep water, in pools, in areas with a slow current, or over heavily silted or mud-covered streambeds. Places selected for egg deposition is determined by the optimal combination of two main interconnecting variables: depth of water and velocity of current.

On both the Asian and North American sides of the Pacific Ocean, pink salmon generally spawn at depths of 30-100 cm. Well populated spawning grounds of pink salmon are mainly at depths of 20-25 cm, less often reaching depths of 100-150 cm. In dry years, when spawning grounds are crowded, nests can be found at shallower depths of 10-15 cm. Current velocities in pink salmon spawning grounds varied from 30 to 100 cm/s, sometimes reaching 140 cm/s. Directly over the redds, about 5-7 cm from the surface, the velocity can range from 30 to 140 cm/s but usually averages from 60 to 80 cm/s.

In general, pink salmon select sites in gravel where the gradient increases and the currents are relatively fast. In these areas, surface stream water must have permeated sufficiently to provide intragravel flow for dissolved oxygen delivery to eggs and alevins. Chum salmon, by contrast, tended to select spawning sites in areas with upwelling spring water and a relatively constant water temperature, without much regard to surface stream water. Pink salmon spawning beds consist primarily of coarse gravel with a few large cobbles, a large mixture of sand, and a small amount of silt. High quality spawning grounds of pink salmon can best be summarized as clean, coarse gravel.

Larvae/alevins: Fertilized eggs begin their five- to eight-month period of embryonic development and growth in intragravel interstices. To survive successfully, the eggs, alevins and pre-emergent fry must first be protected from freezing, desiccation, stream bed scouring or shifting, mechanical injury and predators. Water surrounding them must be non-toxic and of sufficient quality and quantity to provide basic requirements of suitable temperatures, adequate supply of oxygen, and removal of waste materials. Collectively, these requirements are, on average, only partially met even under the most favorable natural conditions. Overall freshwater survival of pink salmon from egg to advanced alevin and emerged fry, even in highly productive streams, commonly reaches only 10%-20% and at times is as low as about 1%.

Rates of egg development, survival, size of hatched alevins and percentage of deformed fry are related to temperature and oxygen levels during incubation. Temporary low stream temperatures or dissolved oxygen concentrations, however, may be relatively unimportant at some developmental stages, but lethal at others. Generally, low oxygen levels are non-lethal early, but lethal late in development. Eggs subjected to low dissolved oxygen levels hatched prematurely at a rate dependent on the degree of hypoxia. Spinal deformities occurred in eggs incubated at 3.0° and 4.5°C before gastrulation. In one study, over 50% of developing pink salmon eggs died at dissolved oxygen levels of 3-4 mg/l, and among those that hatched many alevins were deformed.

Juveniles: Newly emerged pink salmon fry show a preference for saline water over fresh water which may, in some situations, facilitate migration from the natal stream area. Schools of pink salmon fry may move quickly from the natal stream area or remain to feed along shorelines up to several weeks. The timing and pattern of seaward dispersal is influenced by many factors, including general size and location of the spawning stream, characteristics of adjacent shoreline and marine basin topography, extent of tidal fluctuations and associated current patterns, physiological and behavioral changes with growth, and, possibly, different genetic characteristics of individual stocks.

Early marine schools of pink salmon fry, often in tens or hundreds of thousands of fish, tend to follow shorelines and, during the first weeks at sea, spend much of their time in shallow water of only a few centimeters deep. It has been suggested that this onshore period involves a distinct ecological life history stage in both pink and chum salmon. In many areas throughout their ranges, pink salmon and chum salmon fry of similar age and size co-mingle in both large and small schools during early sea life. Juvenile pink salmon in the Bering Sea off the northeastern Kamchatka coast are found in one of three hydrological zones during their first three to four months of marine life: (1) the littoral zone, up to 150 m from shore; (2) open parts of inlets and bays from 150 m to 3.2 km from shore; and (3) the open parts of the large Karaginskiy Gulf, 3.2 to 96.5 km from shore. Distribution within these regions is seasonally related to the size of pinks, with an offshore movement of larger fish in August and September.

Pink salmon juveniles routinely obtain large quantities of food sufficient to sustain rapid growth from a broad range of habitats providing pelagic and epibenthic foods. Collectively, diet studies show that pink salmon are both opportunistic and generalized feeders and on occasion they specialize in specific prey items. Diel sampling of stomachs showed fewer and more digested food items at night than during the day indicating that juvenile pinks are primarily diurnal feeders.

Adults: Ocean growth of pink salmon is a matter of considerable interest because, although this species has the shortest life span among Pacific salmon, it also is among the fastest growing. Entering the estuary as fry at around 3 cm in length, maturing adults return to the same area 14-16 months later ranging in length from 45 to 55 cm.

The population biology of pink salmon revolves around the two-year life cycle. A phenomena of cycle dominance between odd- and even-year brood lines within specific regions is common. Dominance can be weak or strong, complete or non-existent. It can also shift between brood lines. With complete dominance, the “off-year” line is absent while non-dominance is characterized by similar population strength between odd- and even-year runs. Although many causes for dominance and its various characteristics in pink salmon populations have been proposed, none satisfactorily explains the event. Genetically, pink salmon are more similar within odd- or even-year brood lines across broad geographic regions than across brood lines within the same stream. It has been suggested for some geographic areas that present odd- and even-year pink salmon populations arose from separate glacial refuges during late Pleistocene times.

Scientists have recognized six distinct ocean migration patterns for regional stock groups of pink salmon throughout the North Pacific. Only two of these stock groups, those originating in Washington state and British Columbia and those originating in Southeastern, Central and Southwestern Alaska, occur in marine waters where they might interact in some way with the salmon fisheries off the coast of Southeast Alaska. Pink salmon from these two broad stock groups co-mingle in the Gulf of Alaska during their second summer at sea while migrating towards natal areas.

References

Alderdice, D.F., and F.P.J. Velsen. 1978. Relation between temperature and incubation time for eggs of chinook salmon *(Oncorhynchus tshawytscha).* J. Fish. Res. Board Can. 35:69-75.

Alderdice, D.F., W.P. Wickett, and J.R. Brett. 1958. Some effects of temporary exposure to low dissolved oxygen levels on Pacific salmon eggs. J. Fish. Res. Board Can. 15:229-249.

Allen, G.H., and W. Aron. 1958. Food of salmonid fishes of the western North Pacific Ocean. U.S. Fish Wild. Serv. Spec. Sci. Rep. Fish. 237:11 p.

Aron, W.I. 1956. Food of salmonid fishes of the North Pacific Ocean. C. Food of pink salmon *Oncorhynchus gorbuscha. D.* Preliminary comparative study of the feeding behavior of the pink, sockeye and chum salmons. Univ. Wash. Dep. Oceanogr. Fish. Rep. 4:10 p.

Aspinwall, N. 1974. Genetic analysis of North American populations of pink salmon, *Oncorhynchus gorbuscha*, possible evidence for the neutral mutation-random drift hypothesis. Evolution 28:295-305.

Atkinson, C.E., T.H. Rose, and T.O. Duncan. 1967. Pacific salmon in the United States, p. 43-223. *In:* Salmon of the North Pacific Ocean. Part IV. Spawning populations of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 23.

Baggerman, B. 1960. Salinity preference, thyroid activity and the seaward migration of four species of Pacific salmon *(Oncorhynchus). J.* Fish. Res. Board Can. 17:295-322.

Bailey, J.E. 1969. Alaska's fishery resources - the pink salmon. Fish Leafl. (U.S.) 619:8 p.

Bailey, J.E., and D.R. Evans. 1971. The low-temperature threshold for pink salmon eggs in relation to a proposed hydroelectric installation. Fish. Bull. (U.S.) 69:587-593.

Bailey, J.E., S.D. Rice, J.J. Pella, and S.G. Taylor. 1980. Effects of seeding density of pink salmon, *Oncorhynchus gorbuscha*, eggs on water chemistry, fry characteristics, and fry survival in gravel incubators. Fish. Bull. (U.S.) 78:649-658.

Baitey, J.E., B.L. Wing, and J.H. Landingham. 1983. juvenile Pacific sandfish, *Trichodon trichodon,* associated with pink salmon, *Oncorhynchus gorbuscha*, fry in the nearshore area, southeastern Alaska. Copeia. 1983(2):549-551.

Bailey, J.E., B.L. Wing, and C.R. Mattson. 1975. Zooplankton abundance and feeding habits of fry of pink salmon, *Oncorhynchus gorbuscha,* and chum salmon, *Oncorhynchus keta*, in Traitors Cove, Alaska, with speculations on the carrying capacity of the area. Fish. Bull. (U.S.) 73:846-861.

Davidson, F.A. 1934. The homing instinct and age at maturity of pink salmon *(Oncorhynchus gorbuscha).* Bull. Bur. Fish. (U.S.) 48:27-29.

_______. 1935. The development of the secondary sexual characters in the pink salmon (*Oncorhynchus gorbuscha*). J. Morphol. 57:169-183.

Davidson, F.A., E. Vaughan, S.J. Hutchinson, and A.L. Pritchard. 1943. Factors influencing the upstream migration of the pink salmon *(Oncorhynchus gorbuscha).* Ecology 24:149-168.

Donnelly, R.F. 1983. Factors affecting the abundance of Kodiak Archipelago pink salmon *(Oncorhynchus gorbuscha*, Walbaum). Ph.D. thesis. University of Washington, Seattle, WA. 157 p.

Dubrovskaia, N.V. 1934. The life cycle of the pink salmon of Primorye. Rybn. Khoz. 1-2:65-68 (Transl. from Russian; Fish. Res. Board Can. Transl. Ser. 542).

Eniutina, R.I. 1954. Local stocks of pink salmon in the Amur Basin and neighboring waters. Vopr. Ikhtiol. 2:139-143. (Transl. from Russian; Fish. Res. Board Can. Transl. Ser. 284).

Fiscus, C.H. 1980. Marine mammal-salmonid interactions: a review. P. 121-132. *In:* W.J. McNeil and D.C. Himsworth (eds.). Salmonid ecosystems of the North Pacific. Oregon State University Press, Corvallis, OR.

Gerke, R.J., and V.W. Kaczynski. 1972. Food of juvenile pink and chum salmon in Puget Sound, Washington. Wash. Dep. Fish. Tech. Rep.10:27 p.

Gharrett, A.J., C. Smoot, and A.J. McGregor. 1988. Genetic relationships of even-year northwestern Alaskan pink salmon. Trans. Am. Fish. Soc. 117:536-545.

Godin, J.G.J. 1980a. Temporal aspects of juvenile pink salmon *(Oncorhynchus gorbuscha* Walbaum) emergence from a simulated gravel redd. Can. J. Zool. 58:735-744.

_______. 1980b. Ontogenetic changes in the daily rhythms of swimming activity and of vertical distribution in juvenile pink salmon *(Oncorhynchus gorbuscha* Walbaum). Can. J. Zool. 58:745-753.

_______. 1981. Daily patterns of feeding behavior, daily rations, and diets of juvenile pink salmon *(Oncorhynchus gorbuscha)* in two marine bays of British Columbia. Can. J. Fish. Aquat. Sci. 38: 10-15.

Hanavan, M.G., and B.E. Skud. 1954. Intertidal spawning of pink salmon. Fish. Bull. Fish Wild. Serv. 56:167-185.

Healey, M.C. 1967. Orientation of pink salmon (*Oncorhynchus gorbuscha*) during early marine migration from Bella Coola River system. J. Fish. Res. Board Can. 24:2321-2338.

Heard, W.R. 1978. Probable case of streambed overseeding: 1967 pink salmon, *Oncorhynchus gorbuscha*, spawners and survival of their progeny in Sashin Creek, southeastern Alaska Fish. Bull. (U.S.) 76:569-582.

_______. 1991. Life history of pink salmon, *Oncorhynchus gorbuscha*, p 119-230 *in* C. Groot and L. Margolis, eds. Pacific salmon life histories. UBC Press, Vancouver

Helle, J.H. 1966. Behavior of displaced adult pink salmon. Trans. Am. Fish. Soc. 95:188-195.

_______. 1970. Biological characteristics of intertidal and fresh-water spawning pink salmon at Olsen Creek, Prince William Sound, Alaska, 1962- 63. U.S. Fish Wild. Serv. Spec. Sci. Rep. Fish. 602: 19 p.

Helle, J.H., R.S. Williamson, and J.E. Bailey. 1964. Intertidal ecology and life history of pink salmon at Olsen Creek, Prince William Sound, Alaska. U.S. Fish Wild. Serv. Spec. Sci. Rep. Fish. 483: 26 p.

Hoar, W.S. 1951. The chum and pink salmon fisheries of British Columbia 1917-1947. Bull. Fish. Res. Board Can. 90:46 p.

_______. 1956. The behaviour of migrating pink and chum salmon fry. J. Fish. Res. Board Can. 13:309-325.

_______. 1958. The evolution of migratory behaviour among juvenile salmon of the genus *Oncorhynchus.* J. Fish. Res. Board Can. 15:391-428.

Hunter, J.G. 1959. Survival and production of pink and chum salmon in a coastal stream. J. Fish. Res. Board Can. 16:835-886.

Ishida, T. 1966. Pink salmon in the Far East. P. 29-39. *In:* Salmon of the North Pacific Ocean. Part III. A review of the life history of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 18.

Karpenko, V.I. 1979. Feeding habits of juvenile Pacific salmon in the coastal waters of Kamchatka. Sov. J. Mar. Biol. 5:398-405.

_______. 1987. Growth variation of juvenile pink salmon, *Oncorhynchus gorbuscha*, and chum salmon *Oncorhynchus keta*, during the coastal period of life. J. Ichthyol. 27:117-125.

Kirkwood, J.B. 1962. Inshore-marine and freshwater life history phases of pink salmon, *Oncorhynchus gorbuscha* (Walbaum), and the chum salmon, *O. keta* (Walbaum), in Prince William Sound, Alaska. Ph.D. thesis. University of Kentucky, Louisville, KY. 300 p.

Kron, T.M., and H.J. Yuen. 1978. Zooplankton abundance and the feeding habits and migration of juvenile pink salmon, Tutka Bay, Alaska, 1975. Alaska Department of Fish and Game, FRED Division. Anchorage. AK. 25 p.

Krupitskiy, Yu. G., and A.F. Ustyugov. 1977. The pink salmon, *Oncorhynchus gorbuscha*, in the rivers of the north of Krasnoyarsk territory. J. Ichthyol. 17:320-322.

Landingham, J.H. 1982. Feeding ecology of pink and chum salmon fry in the nearshore habitat of Auke Bay, Alaska. M.Sc. thesis. University of Alaska, Juneau, AK. 132 p.

Martin, J.W. 1966. Early sea life of pink salmon. P. 111-125. *In:* W.L. Sheridan (ed.). Proceedings of the 1966 Northeast Pacific Pink Salmon Workshop. Alaska Dep. Fish Game Inf. Leafl. 87.

McDonald, J. 1960. The behaviour of Pacific salmon fry during their downstream migration to freshwater and saltwater nursery areas. J. Fish. Res. Board Can. 17:655-676.

McNeil, W.J. 1962. Mortality of pink and chum salmon eggs and larvae in southeast Alaska streams. Ph.D. thesis. University of Washington, Seattle, WA. 270 p.

Merrell, T.R. 1962. Freshwater survival of pink salmon at Sashin Creek. P. 59-72. *In:* N.J. Wilimovskv (ed.). Symposium on Pink Salmon. H.R. MacMillan Lectures in Fisheries. Institute of Fisheries, University of British Columbia, Vancouver, BC.

Mortensen, D.G. 1983. Laboratory studies on factors influencing the first feeding of newly emerged pink salmon *(Oncorhynchus gorbuscha)* fry. M.Sc. thesis. University of Alaska, Juneau, AK. 108 p.

Murray, C.B., and T.D. Beacham. 1986. Effect of varying temperature regimes on the development of pink salmon *(Oncorhynchus gorbuscha)* eggs and alevins. Can. J. Zool. 64:670-676.

Neave, F. 1948. Fecundity and mortality in Pacific salmon. Proc. Trans. R. Soc. Can. Ser. 3 42(5):97-105.

_______. 1952. “Even-year” and “odd-year” pink salmon populations. Proc. Trans. R. Soc. Can. Ser. 3 46(5):55-70.

_______. 1953. Principles affecting the size of pink and chum salmon populations in British Columbia. J. Fish. Res. Board Can. 9:450-491.

_______. 1955. Notes on the seaward migration of pink and chum salmon fry. J. Fish. Res. Board Can. 12:369-374.

_______. 1958. The origin and speciation of *Oncorhynchus.* Proc. Trans. R. Soc. Can. Ser. 3 52(5):25-34.

_______. 1962. The observed fluctuations of pink salmon in British Columbia. P. 3-14. *In*: N.J. Wilimovsky (ed.). Symposium on Pink Salmon. H.R. MacMillan Lectures in Fisheries. Institute of Fisheries, University of British Columbia, Vancouver, BC.

Neave, F., T. Ishida, and S. Murai. 1967. Salmon of the North Pacific Ocean. Part VI. Pink salmon in offshore waters. Int. North Pac. Fish. Comm. Bull. 22:33 p.

Nicola, S.J. 1968. Scavenging *by Alloperla (Plecop*tera: Chloroperlidae) nymphs on dead pink *(Oncorhynchus gorbuscha)* and chum (O. *keta)* salmon embryos. Can. J. Zool. 46:787-796.

Olson, J.M., and W.J. McNeil. 1967. Research on pink salmon at Little Port Walter, Alaska, 1934-64. U.S. Fish Wild. Serv. Data Rep. 17:301 p.

Parker, R.R. 1962a. A concept of the dynamics of pink salmon populations. P. 203-211. *In*: N.J. Wilimovsky (ed.). Symposium on Pink Salmon. H.R. MacMillan Lectures in Fisheries. Institute of Fisheries, University of British Columbia, Vancouver, BC.

_______. 1962b. Estimations of ocean mortality rates for Pacific salmon *(Oncorhynchus). J.* Fish. Res. Board Can. 19:561-589.

_______. 1968. Marine mortality schedules of pink salmon of the Bella Coola River, central British Columbia. J. Fish. Res. Board Can. 25:757-794.

Pirtle, R.B. 1977. Historical pink and chum salmon estimated spawning escapements from Prince William Sound, Alaska streams, 1960-1975. Alaska Dept. Fish Game, ADF&G Tech. Data Rep. 35:332 p.

Pritchard, A.L. 1934a. Do caddis fly larvae kill fish? Can. Field-Nat. 48:39 p.

_______. 1939. Homing tendency and age at maturity of pink salmon *(Oncorhynchus gorbuscha)* in British Columbia. J. Fish. Res. Board Can. 4:233-251.

_______. 1948b. A discussion of the mortality in pink salmon *(Oncorhynchus gorbuscha)* during their period of marine life. Proc. Trans. R. Soc. Can. Ser. 3 42(5):125-133.

Ricker, W.E. 1962. Regulation of the abundance of pink salmon populations. P. 155-206. *In:* N.J. Wilimovsky (ed.). Symposium on Pink Salmon. H.R. MacMillan Lectures in Fisheries. Institute of Fisheries, University of British Columbia, Vancouver, BC.

Royce, W.F. 1962. Pink salmon fluctuations in Alaska. P. 15-23. *In:* N.J. Wilimovsky (ed.). Symposium on Pink Salmon. H.R. MacMillan Lectures in Fisheries. Institute of Fisheries, University of British Columbia, Vancouver, BC.

Sakagawa, G.T. 1972. The dynamics of juvenile salmon, with particular emphasis on pink salmon *(Oncorhynchus gorbuscha),* during their early marine life. Ph.D. thesis. University of Washington, Seattle, WA. 352 p.

Shershnev, A.P., V.M. Chupakhin, and V.A. Rudnev. 1982. Ecology of juvenile pink salmon, *Oncorhynchus gorbuscha* (Salmonidae), from Sakhalin and Iturup islands during the marine period of life. J. Ichthyol. 22:90-97.

Skud, B.E. 1958. Relation of adult pink salmon size to time of migration and freshwater survival. Copeia 1958:170-176.

Takagi, K., K.V. Aro, A.C. Hartt, and M.B. Dell. 1981. Distribution and origin of pink salmon *(Oncorhynchus gorbuscha)* in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 40:195 p.

Taylor, S.G. 1980. Marine survival of pink salmon fry from early and late spawners. Trans. Am. Fish. Soc. 109:79-82.

Thorsteinson, F.V. 1959. Pink salmon migrations along the Alaska Peninsula. P. 1-7. *In:* Alaska fisheries briefs. U.S. Fish Wild. Serv. Circ. 59.

Vallion, A.C., A.C. Wertheimer, W.R. Heard, and R.M. Martin. 1981. Summary of data and research pertaining to the pink salmon population at Little Port Walter, Alaska, 1964-80. NWAFC Processed Rep. 81-10:102 p.

Yefanov, V.N., and V.M. Chupakhin. 1982. The dynamics of some population indices of pink salmon, *Oncorhynchus gorbuscha,* from Iturup (Kuril Islands). J. Ichthyol. 22:42-50.

SPECIES: Pink salmon, *Onchorynchus gorbuscha*

Stage - EFH Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs and larvae EFH LEVELS 1-3	90-125 d	eggs predated by birds, fish and mammals	late summer, fall, winter, and early spring	intragravel in stream beds WC, LK, BHC	15 to 50 cm in gravel depth	medium to course gravel CB, G	NA	Develop at 1-10°C, eggs hatch at about 100 d, larvae emerge from gravel about 125 d post hatch
Juveniles, freshwater EFH LEVELS 0-3	1-15 d; short streams = 1d, longer rivers=15 d	fry are predated by birds, fish and mammals	spring	rivers and streams WC, LK, BHC	generally migrating in upper portion of water column	varied	NA	downstream migration is mostly in darkness
Juveniles, estuarine EFH LEVELS 0-3	2-3 months	copepods, euphausiids, decapod larva, amphipods	summer	EST, initially nearshore, then offshore in bays and inlets , along kelp beds	generally occupying the upper portion of water column	varied: K, SAV	NA	Preference for increasing salinities, school with other salmon and Pacific sandfish
Juveniles, marine EFH LEVELS 0-3	3 to 6 months	copepods, euphausiids, decapod larva, amphipods	summer, fall, and early, pre annlus winter	coastal, ICS, MCS, OCS; moving further offshore with growth	generally migrating in upper portion of water column	varied: K, SAV	UP, F, CL, E	Coastal and shelf migrations move into oceanic waters in later stages

Immature and maturing adults marine EFH LEVELS 0-3	6 to 10 months	fish, squid, euphausiids, amphipods, and copepods	spring, summer, and early fall	Oceanic to nearshore in final migration	P, N	NA	UP, F, CL, E: Regional stocks have specific oceanic migratory patterns	Rapid marine growth; onset of maturation timing varies among stocks; earlier north, later south
Adults, freshwater EFH LEVELS 1-3	2 yrs of age from egg to mature adult, final stage 1-2 months	Active feeding ceases, digestive ogans atrophy	spawning (Aug-Oct)	WC, LK, BCH	Varied, holding in pools, spawning on shallow riffles	medium to course gravel CB, G	NA	sexual dimorphism in spawning males, called humpback salmon

WC= water course, rivers, streams, sloughs; LK= lakes, and pond; BCH= beach (intertidal); ICS= inner continental shelf (1-50 m); MCS= middle continental shelf (50-100 m); OCS= outer continental shelf (100-200 m); EST= estuarine, intermediate salinities, nearshore bays with inlet watercourses, eel grass beds, fiords; P= pelagic (found off bottom, not necessarily associated with a particular bottom type); N= neustonic (found near surface); CB=cobble; G= gravel; K= kelp; SAV= submerged aquatic vegetation (e.g., eel grass, not kelp); UP= upwelling; F= fronts; CL= thermo or pycnocline; E= edges; NA=not applicable.

See table of contents for the following figures:

Figure 1. Indigenous spawning distribution of pink salmon throughout coastal waters of the North Pacific Ocean, Arctic Ocean and adjacent seas.

Figure 2. Diagram of ocean migration of pink salmon originating in Washington and British Columbia.

Figure 3. Diagram of ocean migration of pink salmon originating in southeastern, central and southwestern Alaska.

Figure 4. Marine EFH for pink salmon: the general distribution of immature and maturing pink salmon to the limits of the US EEZ off Alaska. Westward areas within the US EEZ not shown on the map are also EFH for pink salmon.

Habitat Description for Chum salmon
(*Oncorhynchus keta)*

Management Plan and area(s): Salmon Fisheries in the EEZ Off the Coast of Alaska, NPFMC, 1990

Life History and General Distribution

Chum salmon spawn in streams emptying into the North Pacific Ocean north of about 40°N in both Asia and North America. In Asia chum salmon spawn in streams on the east side of the Korean peninsula in both South and North Korea northward, including Japan, China (tributaries to the Amur River), Russia and westward into the Arctic Ocean as far west as the Lena River. In North America chum salmon spawn in streams entering the North Pacific Ocean as far south as northern California and northward in streams along the coasts of Oregon, Washington, British Columbia, and Alaska on into the Bering Sea, Arctic Ocean and Beaufort Sea as far east as the Mackenzie River in Northwest Territory. Chum salmon spawn in Yukon Territory, Canada, in tributaries of the Yukon River. Only populations small in numbers spawn north and east of the Noatak River, which enters the ocean at Kotzebue, Alaska, and south of Tillamook Bay, Oregon.

In general, chum salmon spawn in the lower reaches of coastal streams less than 100 miles upstream from the ocean. Two notable exceptions are the Yukon River in North America and the Amur River in Russia and China where chum salmon migrate upstream more than 1,500 miles to spawning areas. In Prince William Sound, and to a lesser extent Southeast Alaska, chum salmon will spawn in the intertidal portions of streams in areas where ground water upwells into the streams. Chum salmon throughout their range tend to build their redds in areas of streams where ground water (about 4 to 7 C.) upwells.

In North America chum salmon return from the ocean to spawn, for the most part, between June and January. In general, spawning starts earlier in the north and ends later in the southern part of their range. Of course, major exceptions in this pattern occur. The latest spawning in Southeast Alaska occurs in the Chilkat River, near Haines, Alaska, in September through January. Most chum salmon spawning in Alaska is usually finished by early November. Most spawning in Washington/Oregon takes place in August through November; however, August spawners have been declining in recent years. Chum salmon return to the Quilcene National Fish Hatchery in December and the Nisqually River, near Olympia, Washington has spawners during January and February and sometimes into March.

So called summer and fall races of chum salmon occur in Asia and North America. Summer and fall races both enter the Yukon River. The summer chum salmon start entering the river in May and the fall chum enter the river in June and July. The fall stocks tend to spawn farthest up river in September through November. Summer chum are more abundant than fall chum in the Yukon River; however, the fall chum are larger. In southern Southeast Alaska and northern British Columbia summer chum enter mostly mainland rivers in mid June and spawning may extend into late October and early November. Fall chum in southern Southeast Alaska and northern British Columbia spawn mostly in streams on the Islands and spawning typically occurs during September and October. Unlike the Yukon River, summer chum salmon in southern Southeast Alaska and northern British Columbia are larger than the fall stocks for the same age, even though the summer stocks may spawn more than 3 months earlier.

Chum salmon return to spawn as 2- to 7-year olds. Two-year old chum are rare in North America and occur primarily in the southern part of their range, e.g., Oregon. Seven-year old chum are also rare and occur mostly in the northern areas. In general, chum salmon get older from south to north. Three- and four-year olds tend to dominate in the southern areas and four, five, and six-year olds tend to dominate in the more northern areas. For the most part older chum salmon are larger than younger fish but much overlap occurs between the age groups. The largest chum salmon in North America (and probably the world) occur in the Portland Canal area which forms the border between Alaska and British Columbia.

Chum salmon fry, like pink salmon, do not overwinter in the streams but migrate (mostly at night) out of the streams directly to the sea shortly after emergence. The range of this outmigration occurs between February and June but most fry leave the streams during April and May. Chum salmon do tend to linger and forage in the intertidal areas at the head of bays. Estuaries are very important for chum salmon rearing during the spring and summer.

Juvenile chum salmon are present in the coastal waters mostly during July through October(?), and generally move to the north and west along the coasts of Oregon, Washington, British Columbia, and Alaska. Most juvenile chum salmon are thought to leave the coastal waters and move south into the North Pacific Ocean between Kodiak and False Pass during late fall. After chum salmon form an annulus on their scales (January - March) they are considered immature. They may remain immature for several years until they start maturing and begin their migration to their spawning streams.

Both Asian and North American chum salmon winter in the North Pacific but Asian chum salmon migrate much further east than North American chum salmon migrate to the west. North American chum salmon are seldom found west of 175°E, however, Asian salmon are found eastward to at least 140°W. However, Asian and North American stocks of chum salmon are intermingled on the high seas.

After the 1976-77 Regime Shift in the North Pacific Ocean most chum salmon stocks increased in abundance through the mid-1990s. The Regime Shift apparently created very favorable ocean conditions for all species of salmon from northern British Columbia to northern Alaska. However, as the abundance increased age at maturity increased and the size at age decreased drastically. Chum salmon of the same age in the early 1990s weighed up to 46% less than they weighed in the early 1970s. During this same time, Asian chum salmon also matured older and their size at age declined. These changes in size and age at maturity as population numbers increased suggests that the North Pacific Ocean may have carrying capacity limits for chum salmon under certain conditions.

<u>Fisheries</u>

Chum salmon are captured primarily in purse seines and gill-nets in North America after traps were outlawed in Alaska in 1960. Some chum salmon are captured in troll fisheries, primarily in Canada.

Major fisheries occur for chum salmon from southern Washington to the Noatak River in northwestern Alaska. Significant declines of chum salmon in Oregon in the 1940s caused the state to abandon net fisheries and the stocks still have not recovered.

Most net fisheries for chum salmon occur in the coastal waters in Alaska but some in-river gill-net fisheries occur in the larger rivers for both commercial and subsistence fisheries. Chum salmon are often captured incidently in fisheries targeting pink or sockeye salmon. Large incidental catches of chum salmon occur in Southeast Alaska and Prince William Sound. When the Pacific Salmon Treaty between the U.S.A. and Canada was signed in 1984 chum salmon in Portland Canal (on both sides of the border but particularly in Canada) were identified as a major conservation concern. The cause of this problem was blamed on incidental capture of chum salmon in fisheries targeting pink and sockeye salmon.

Chum salmon have also been captured incidentally in the trawl fisheries for pollock in the Bering Sea. Apparently, the chum are “scooped” at the surface when the trawl is being let out and brought in. In some years this can be a major problem, e.g., in 1994 when about 250,000 chum were estimated to be part of the bycatch.

Relevant Trophic Information

Chum salmon eggs, alevins, and juveniles in freshwater streams provide an important food source for many birds (e.g., gulls, crows, magpies, ouzels, kingfishers), small mammals, other fishes, and many invertebrates. Chum salmon carcasses provide nutrients for the freshwater watersheds and estuaries. Carcasses are also highly important for food for many birds (e.g., eagles, ravens, crows, gulls, magpies). The late chum salmon return to the Chilkat River system near Haines, Alaska, is the reason that large numbers of bald eagles congregate on the spawning grounds every year in September through December. Adult chum salmon and spawned carcasses provide a major food source for brown and black bears, wolverines, wolves, and many other small mammals. Many species of invertebrates utilize carcasses for food.

Potential Gear Impacts on Habitats of Chum or other Species of Fish

Chum salmon fisheries utilize seines, gill-nets, and troll gear and there are no apparent impacts of the gear on marine or freshwater habitats.

Upper Size Limit of Juvenile Fish

If the term juvenile chum salmon refers to the fry stage up to the time of the first annulus formation in the ocean, which occurs in January-March, the upper size limit is about 30 cm. Juvenile chum salmon in the outside waters of Southeast Alaska in mid to late August range in size up to about 25 cm.

Sources of Additional Data

Ben van Alen, Alaska Department of Fish and Game, Douglas, (907) 465-4250
Christene Kondzela, NMFS, Auke Bay Laboratory, Juneau, (907) 789-6084

Habitat and Biological Associations

Eggs and Spawning: Chum salmon spawn in gravel in streams, side-channel sloughs, and intertidal portions of streams when the tide is below the spawning area. In all of these areas upwelling ground water is often the common denominator. Many side-channel sloughs have very little current on the surface and can be very silty; however, the upwelling ground water keeps the silt in suspension in the intragravel water. The upwelling water also keeps these spawning areas with slow moving surface water from freezing in the winter. The depth that eggs are deposited in the streams varies according to the gravel size, current, and size of the female but the range is about 8 to 50 cm. Eggs and sperm are deposited in the redd simultaneously and each female spawns with up to 6 males at the same time. Several redds are constructed by each female and different males may be involved in the spawning act in subsequent redds. Stream life of both sexes varies and is longer in the early stages of the run (about 14 days) and shorter near the end of the run (as few as 6 days) in coastal streams.

Larvae/alevins: Fertilized eggs incubate in the streambed gravel for about five to eight months. Eggs, alevins, and pre-emergent fry can be killed by desiccation, freezing, mechanical injuries due to streambed shifting, e.g., during floods, and predators. The intragravel water during incubation and rearing must be of suitable temperatures and be free of toxins with adequate oxygen and flow to remove waste products. Survival from deposited eggs to emergent fry is highly variable, ranging from about 1% to 20%. The health of the eggs and emerging fry is also dependent on gravel composition, spawning time, spawning density, and genetic characteristics. In general chum salmon eggs have to be fertilized in

water above 4 C. and in salinity less than 2 parts per thousand. Dissolved oxygen levels during incubation need to be above 3 to 4 mg/l.
Juveniles: After emerging from the streambed (as early as February and as late as June) schooling chum salmon fry migrate downstream, mostly at night, to the estuaries where they tend to feed in the intertidal grass flats and along the shore. Chums can utilize these intertidal wetlands for several months before actively migrating out of bays and into channels on the way to the outside waters. Pink salmon on the other hand tend to move more directly to more open water areas. Chum salmon utilize a wide variety of food items, including mostly invertebrates (including insects), and gelatinous species. Offshore movement of larger juveniles occurs mostly in July - September.

Adults: Chum salmon reside in the ocean for about one to six years. Adults mature at ages 2 through 7 years; however, 2- and 7-year old chum salmon are rare. Throughout their range 3-, 4-, and 5-year olds are common but 3- and 4-year old salmon dominate the southern stocks and 4-, 5-, and 6-year old chum salmon dominate the northern stocks. Slow or rapid growth in the ocean can modify age at maturity. Slower growth during the second year at sea causes some chum salmon to mature one or two years later. Chum salmon eat a variety of foods during their ocean life, e.g., amphipods, euphausiids, pteropods, copepods, fish, and squid larvae. Chum salmon also utilize gelatinous zooplankton for food more often than any of the other species of salmon. Chum salmon have a much larger stomach than the other species of salmon and this large capacity may allow them to utilize the nutrients from the gelatinous zooplankton more efficiently.

Asian and North American chum salmon are intermingled on the high seas as immature and during their last year at sea. Recently, immature and maturing chum salmon from Washington, British Columbia, and southeast Alaska have been identified in the Bering Sea in August. Chum salmon spawn mostly in November in Washington and southern British Columbia so these fish are capable of long distant migrations in their last year in the sea.

<u>Special Habitat Concerns</u>: Chum salmon are subject to the same habitat concerns as the other species of salmon, e.g., habitat destruction or silting due to logging and road building activities, blockages due to dams, and pollution. In addition, chum salmon have two habitat requirements that are essential in their life history that make them very vulnerable: (1) reliance on upwelling ground water for spawning and incubation, and (2) reliance on estuaries/tidal wetlands for juvenile rearing after migrating out of the streams. The hydrology of upwelling ground water into stream gravel is highly complex and poorly understood. Whatever activities change the amount and quality of ground water that upwells would very likely affect chum salmon survival in a negative manner. Drilling activities and uplift of land masses due to earthquakes are two phenomena known to affect ground water. Wetlands and estuaries near communities are very vulnerable to pollution and filling activities that would negatively affect essential chum salmon rearing areas.

Chum salmon will spawn in intertidal portions of streams, most notably in Prince William Sound. The intertidal portion of streams is very vulnerable to coastal pollution from oil spills et al. In Prince William Sound, chum salmon spawners are active in the intertidal zone of streams from late June through September. Eggs, alevins, and fry are in the intertidal gravel from late June through May. That leaves a very narrow “window” in June when the intertidal zone may be free of adults, eggs, alevins, or fry.

References

Alderdice, D. F., W. P. Wickett, and J. R. Brett. 1958. Some effects of temporary exposure to low dissolved oxygen levels on Pacific salmon eggs. J. Fish. Res. Board Can. 15: 229-249.

Aro, K. V., and M. P. Shepard. 1967. Pacific salmon in Canada, p. 225-327. *In*: Salmon of the North Pacific Ocean. Part IV. Spawning populations of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 23.

Atkinson, C. E., J. H. Rose, and R. O. Duncan. 1967. Pacific salmon in the United States, p. 43-224. *In*: Salmon of the North Pacific Ocean. Part IV. Spawning populations of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 23.

Bailey, J. E., B. L. Wing, and C. R. Mattson. 1975. Zooplankton abundance and feeding habits of fry of pink salmon, *Oncorhynchus gorbuscha*, and chum salmon, *Oncorhynchus keta*, in Traitors Cove, Alaska, with speculation on the carrying capacity of the area. Fish. Bull. (U.S.) 73: 846-861.

Bakkala, R. G. 1970. Synopsis of biological data on the chum salmon, *Oncorhynchus keta* (Walbaum) 1792. FAO Fish. Synop. 41: U.S. Fish. Wildl. Serv. Circ. 315: 89 p.

Bams, R. A. 1970. Evaluation of a revised hatchery method tested on pink and chum salmon fry. J. Fish. Res. Board Can. 27: 1429-1452.

Beacham, T. D. 1982. Fecundity of coho salmon (*Oncorhynchus kisutch*) and chum salmon (*O. keta*) in the northeast Pacific Ocean. Can. J. Zool. 60: 1463-1469.

Beacham, T. D. 1984a. Age and morphology of chum salmon in southern British Columbia. Trans. Am. Fish Soc. 113: 727-736.

Beacham, T. D., and C. B. Murray. 1986. Comparative developmental biology of chum salmon (*Oncorhynchus keta*) from the Fraser River, British Columbia. Can. J. Fish. Aquat. Sci. 43: 252-262.

Beacham, T. D., and C. B. Murray. 1987. Adaptive variation in body size and developmental biology of chum salmon (*Oncorhyunchus keta*) in British Columbia. Can. J. Fish. Aquat. Sci. 44: 244-261.

Beacham, T. D., and P. Starr. 1982. Population biology of chum salmon, *Oncorhynchus keta*, from the Fraser River, British Columbia. Can. J. Fish. Aquat. Sci. 43: 252-262.

Beacham, T.D., F.C. Withler, and R.B. Morley. 1985. Effect of egg size on incubation time and alevin and fry size in chum salmon (*Oncorhynchus keta*) and coho salmon. (*O. kisutch*). Can. J. Zool. 63: 847-850.

Beacham, T.D., R.E. Withler, and A.P. Gould. 1985. Biochemical genetic stock identification of chum salmon (*Oncorhynchus keta*) in southern British Columbia, 1985. Can. J. Fish. Aquat. Sci. 43: 437-448.

Beamish, R J., and D.R. Bouillon. 1993. Pacific salmon production trends in relation to climate. Can. J. Fish. Aquat. Sci. 50: 1004-1016.

Bigler, B.S., D.W. Welch, and J.H. Helle. 1996. A review of size trends among North Pacific salmon *(Oncorhynchus* spp.). Can J. Fish. Aquatic. Sci. 53: 455-465.

Bilton, H.T., and S. A M. Ludwig. 1966. Times of annulus formation on scales of sockeye, pink, and chum salmon in the Gulf of Alaska. J. Fish. Res. Board Can. 23: 1403-1410.

Birman, I. B. 1951. Qualitative characteristics of the stocks and the dynamics of abundance of the autumn chum salmon in the Amur River. Izv. Tikhookean. Nauchno-lssled. Inst. Rybn. Khoz. Okeanogr. 35: 17-31. (Transl. from Russian; Fish. Res. Board Can. Transl. Ser. 349).

Dill, L. M., and T. G. Northcote. 1970. Effects of some environmental factors on survival, condition, and timing of emergence of chum salmon fry (*Oncorhyunchus keta*). J. Fish. Res. Board Can. 27: 196-201.

Forbes, L. S., and R. M. Peterman. 1994. Simple size-structured models of recruitment and harvest in Pacific salmon *(Oncorhynchus* spp.). Can. J. Fish. Aquat. Sci. 51: 603-616.

Freeland, H. J. 1990. Sea surface temperatures along the coast of British Columbia: regional evidence for a warming trend. Can. J. Fish. Aquat. Sci. 47: 346-350.

Gilbert, C. H., and W. H. Rich. 1927. Second experiment in tagging salmon in the Alaska Peninsula fisheries reservation, summer of 1923. Fish. Bull. U.S. 42: 27-75.

Hare, S. R., and R. C. Francis. 1995. Climate change and salmon production in the northeast Pacific Ocean. Can. Spec. Publ. Fish. Aquat Sci. 121: 357-372.

Healey, M. C. 1982b. Timing and relative intensity of size selective mortality of juvenile chum salmon *(Oncorhynchus keta)* during early sea life. Can. J. Fish. Aquat. Sci. 39:952-957.

Helle, J. H. 1979. Influence of marine environment on age and size-at-maturity, growth, and abundance of chum salmon, *Oncorhynchus keta* (Walbaum), from Olsen Creek, Prince William Sound, Alaska. Ph.D. thesis, Oregon State University, Corvallis, OR. 118 p.

Helle, J. H. 1981. Significance of the stock concept in artificial propagation of salmonids in Alaska. Can. J. Fish. Aquat. Sci. 38: 1665-1671.

Helle, J. H. 1984. Age and size-at-maturity of some populations of chum salmon in North America, p. 126-143. *In* P. A. Moiseev [ed.], Proceedings of the Pacific Salmon Biology Conference, 3-13 Oct. 1978, Yuzhno-Sakhalinsk, USSR. Pacific Scientific Institute of Fisheries and Oceanography (TINRO), 4 Shevchenko Alley, 690600, Vladivostok, USSR.

Helle, J. H. 1989. Relation between size-at-maturity and survival of progeny in chum salmon, *Oncorhynchus keta* (Walbaum). J. Fish. Biol. 35 (Suppl. A): 99-107.

Helle, J. H., and M. S. Hoffman. 1995. Size decline and older age-at-maturity of two chum salmon *(Oncorhynchus keta)* stocks in western North America, 1972-92. *In* Climate change and northern fish populations. Edited by R. J. Beamish. Can. Spec. Publ. Fish. Aquat. Sci. 121: 245-260.

Helle, J. H., and M. S. Hoffman. 1998. Changes in size and age at maturity of two North. American stocks of chum salmon (*Oncorhynchus keta)* before and after a major regime shift in the North Pacific Ocean. North Pacific Anadromous Fish Commission. Bulletin No. 1, 81-89.

Henry, K.A. 1953. Analysis of factors affecting the production of chum salmon (*Oncorhynchus keta*) in Tillamook Bay. Fish. Comm. Oreg. Contrib. 18: 37 p.

Henry, K.A. 1954. Age and growth study of Tillamook Bay chum salmon (*Oncorhynchus keta*). Fish. Comm. Oreg. Contrib. 19: 28 p.

Hoar, W. S. 1958. The evolution of migratory behaviour among juvenile salmon of the genus *Oncorhynchus*. J. Fish. Res. Board Can. 15: 391-428.

Hunter, J. G. 1959. Survival and production of pink and chum salmon in a coastal stream. J. Fish. Res. Board Can. 16: 835-886.

Ishida, Y., S. Ito, M. Kaeriyama, S. McKinnell, and K. Nagasawa. 1993. Recent changes in age and size of chum salmon *(Oncorhynchus keta)* in the North Pacific Ocean and possible causes. Can. J. Fish. Aquat. Sci. 50: 290-295.

Kaeriyama, M. 1989. Aspects of salmon ranching in Japan. Physiol. Ecol. Jpn. Spec. Vol. 1: 625-638.

Kaeriyama, M. 1996. Population dynamics and stock management of hatchery-reared salmons in Japan. Bull. Natl. Res. Inst. Aquacult. (Suppl. 2): 11-15.

Kondzela, C. M., C. M. Guthrie, S. L. Hawkins, C. D. Russell, J. H. Helle, and A. J. Gharrett. 1994. Genetic relationships among chum salmon populations in southeast Alaska and northern British Columbia. Can. J. Fish. Aquat. Sci. 51(Suppl. 1):50-64

Koski, K V. 1975. The survival and fitness of two stocks of chum salmon (*Oncorhynchus keta*) from egg deposition to emergence in a controlled-stream environment at Big Beef Creek. Ph.D. thesis. University of Washington, Seattle, WA. 212 p.

LaLanne, J. J. 1971. Marine growth of chum salmon. Int. North Pac. Fish. Comm. Bull. 27: 71-91.

LeBrasseur, R. J. 1969. Growth of juvenile chum salmon (*Oncorhynchus keta*) under different feeding regimes. J. Fish. Res. Board Can. 26: 1631-1645.

Manzer, J. I., T. Ishida, A. E. Peterson, and M. G. Hanavan. 1965. Salmon of the North Pacific Ocean. Part V. Offshore distribution of salmon. Int. North Pac. Fish. Comm. Bull. 15.

Marr, J.C. 1943. Age, length and weight studies of three species of Columbia River salmon *(Oncorhynchus keta, O. gorbuscha* and *O. kisutch).* Stanford Ichthyol. Bull. 2: 157-197.

Mason, J.C. 1974. Behavioral ecology of chum salmon fry (*Oncorhynchus keta*) in a small estuary. J. Fish. Res. Board Can. 31: 83-02.

McNeil, W. J. 1966. Effect of the spawning bed environment on reproduction of pink and chum salmon. Fish. Bull. (U.S.) 65: 495-523.

Miller, A.J., D.R. Cayan, T. P. Barnett, N. E. Graham, and J. M. Oberhuber. 1994. The 1976-77 climate shift of the Pacific Ocean. Oceanography 7(1): 21-26.

Myers, K. W., K. Y. Aydin, R. V. Walker, S. Fowler, and M. L. Dahlberg. 1996. Known ocean ranges of stocks of Pacific salmon and steelhead as shown by tagging experiments, 1956-1995. NPAFC Doc. No. 192. Fisheries Research Institute, University of Washington, Seattle, WA.

Neave, F. 1953. Principles affecting the size of pink and chum salmon populations in British Columbia. J. Fish. Res. Board Can. 9: 450-491.

Neave, F. 1958. The origin and speciation of *Oncorhynchus.* Proc. Trans. R. Soc. Can. Ser. 3 52(5): 25-39.

Neave, F., T. Yonemori, and R. G. Bakkala. 1976. Distribution and origin of chum salmon in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 35. 79 p.

Oakley, A. L. 1966. A summary of information concerning chum salmon in Tillamook Bay. Res. Briefs Fish Comm. Oreg. 12(1): 5-21.

Ogura, M., and S. Ito. 1994. Change in the known ocean distribution of Japanese chum salmon, *Oncorhynchus keta*, in relation to the program of stock enhancement. Can. J. Fish. Aquat. Sci. 51: 501-505.

Pearcy, W. G. 1992. Ocean ecology of North Pacific salmonids. Washington Sea Grant Program, University of Washington Press, Seattle, WA. 179 p.

Pirtle, R. B. 1977. Historical pink and chum salmon estimated spawning escapements from Prince William sound, Alaska streams, 1960-1975. Alaska Dept. Fish & Game, ADF&G Tech. Data Rep. 35:332P.

Ricker, W. E. 1964. Ocean growth and mortality of pink and chum salmon. J. Fish. Res. Board Can. 21: 905-931.

Ricker, W. E. 1972. Hereditary and environmental factors affecting certain salmonid populations. P. 19-160 *In* R. C. Simon and P. A. Larkin [ed.} The stock concept in Pacific salmon. H. R. MacMillan Lectures in Fisheries, University of British Columbia.

Salo, E. O. 1988. Chum salmon as indicators of ocean carrying capacity, p. 81-85. *In* W.J. McNeil [ed.], Salmon production, management, and allocation. Oregon State University Press, Corvallis.

Salo, E. O. 1991. Life history of chum salmon *(Oncorhynchus keta), p.* 233-309. *In C.* Groot and L. Margolis [eds.], Pacific salmon life histories. University of British Columbia Press, Vancouver, B.C.

Sano, S. 1966. Chum salmon in the Far East, p. 4-58. *In*: Salmon of the North Pacific Ocean. Part III. A review of the life history of the North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 18.

Sano, S. 1967. Chum salmon in the Far East, p. 23-42. *In*: Salmon of the North Pacific Ocean. Part IV. Spawning populations of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 23.

Schroder, S. L. 1981. The role of sexual selection in determining overall mating patterns and mate choice in chum salmon. Ph.D. thesis. University of Washington, Seattle, WA. 274 p.

Shepard, M. P., A. C. Hartt, and T. Yonemori. 1968. Salmon of the North Pacific Ocean. Part VIII. Chum salmon in offshore waters. Int. North Pac. Fish. Comm. Bull. 25: 69 p.

Thorsteinson, F. V., J. H. Helle, and D. G. Birkholz. 1971. Salmon survival in intertidal zones of Prince William Sound streams in uplifted and subsided areas, p.194-219. *In:* The great Alaska earthquake of 1964: biology. Natl. Acad. Sci. NAS Publ. 1604.

Thorsteinson, F.V., W.H. Noerenberg, and H.D. Smith. 1963. The length, age, and sex ratio of chum salmon in the Alaska Peninsula, Kodiak Island, and Prince William Sound areas of Alaska. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. 430:84 p.

Welch, D. W. 1997. Anatomical specialization in the gut of Pacific salmon (*Oncorhynchus)*: evidence for oceanic limits to salmon production? Can. J. Zool. 75: 936-942.

SPECIES: Chum salmon, *Onchorhynchus keta*

Stage - EFH Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs and larvae EFH LEVELS 1-3	90-125 d	eggs predated by birds, fish and mammals	early summer, fall, winter, and early spring	intragravel in stream beds WC, LK, BCH	7.5 to 50 cm in gravel depth	small to coarse gravel CB, G	NA	Develop at 1-10°C, eggs hatch at 52-173 d, larvae emerge from gravel 146-325 d
Juveniles (freshwater) EFH LEVELS 0-3	1-15 d; short streams = 1d, longer rivers=30 d	fry are predated by birds, fish and mammals	spring	rivers and streams WC, LK, BCH	generally migrating in upper portion of water column	varied	NA	downstream migration is mostly in darkness
Juveniles (estuarine) EFH LEVELS 0-3	2-3 months	copepods, euphausiids, decapod larva, amphipods, gelatinous zooplankton	summer	EST, initially nearshore, then offshore in bays and inlets , along kelp beds	generally occupying the upper portion of water column	varied: K, SAV	NA	Preference for increasing salinities, school with other salmon and Pacific sandfish
Juveniles, (marine) EFH LEVELS 0-3	3 to 6 months	copepods, euphausiids, decapod larva, amphipods, gelatinous zooplankton	summer, fall, and winter prior to annulus formation in Jan.-Mar.	coastal, ICS, MCS, OCS; moving further offshore with growth	generally migrating in upper portion of water column	varied: K, SAV	UP, F, CL, E	Coastal and shelf migrations move into oceanic waters in later stages

Immature and maturing adults (marine) EFH LEVELS 0-2	6 to 10 months	fish, squid, euphausiids, amphipods, copepods, and gelatinous zooplankton	spring, summer, and early fall	Oceanic to nearshore in final migration	P, N	NA	UP, F, CL, E: Regional stocks have specific oceanic migratory patterns	Rapid marine growth; onset of maturation timing varies widely among stocks; generally earlier north, later south
Adults (freshwater) EFH LEVELS 1-3	2-7 yrs of age from egg to mature adult, final stage 1-2 months	Active feeding ceases, digestive organs atrophy	spawning (June-January)	WC, LK, BCH	Varied, holding in pools, spawning on shallow riffles, pools or side-channel sloughs	small to coarse gravel CB, G	NA	sexual dimorphism in spawners, males develop large teeth, called dog salmon

WC= water course, rivers, streams, sloughs; LK= lakes, and pond; BCH= beach (intertidal); ICS= inner continental shelf (1-50 m); MCS= middle continental shelf (50-100 m); OCS= outer continental shelf (100-200 m); EST= estuarine, intermediate salinities, nearshore bays with inlet watercourses, eel grass beds, fiords; P= pelagic (found off bottom, not necessarily associated with a particular bottom type); N= neustonic (found near surface); CB=cobble; G= gravel; K= kelp; SAV= submerged aquatic vegetation (e.g., eel grass, not kelp); UP= upwelling; F= fronts; CL= thermo or pycnocline; E= edges; NA=not applicable.

See table of contents for the following figures:

Figure 1. Generalized freshwater and ocean distribution of chum salmon. (from Neave et al. 1976)

Figure 2. Model of migration of North American chum salmon. (from Fredin et al. 1977)

Figure 3. Marine EFH for salmon: the general distribution and areas of known concentration of immature and maturing chum salmon to the limits of that US EEZ off Alaska. Areas of concentration are based on NMFS research sampling in July - August 1996 - 1997 and observed concentrations of chum salmon bycatch in the Bering Sea trawl fishery and the False Pass purse seine fishery. Westward areas within the US EEZ not shown on the map are also EFH for chum salmon.

Habitat Description for Sockeye (Red) Salmon
(*Oncorhynchus nerka*)

<u>Management Plan and Area(s)</u> Salmon Fisheries in the EEZ Off the Coast of Alaska, NPFMC, 1990

<u>Life History and General Distribution</u>

The natural freshwater range of sockeye salmon includes the Pacific rim of Asia and North America north of about 40°N. Within this area, the primary spawning grounds of sockeye salmon in North America extend from tributaries of the Columbia River to the Kuskokwim River in western Alaska, and on the Asian side, the spawning areas are found mainly on the Kamchatka Peninsula. Spawning populations become more irregular and occasional north of the Bering Strait, on the north coast of the Sea of Okhotsk, and in the Kuril Islands. Centers of the two largest spawning complexes in the North Pacific rim occur in the Bristol Bay watershed of southwestern Alaska and the Fraser River drainage of British Columbia. In marine environments along both the Asian and North American coastlines sockeye salmon occupy ocean waters south of the limits of spawning systems.

Sockeye salmon exhibit a greater variety of life history patterns than other members of the genus *Oncorhynchus*, and characteristically make more use of lake rearing habitat in juvenile stages. Although sockeye salmon are primarily anadromous, there are distinct populations called kokanee which mature, spawn and die in fresh water without a period of sea life. Typically, but not universally, juvenile anadromous sockeye utilize lake rearing areas for one to three years after emergence from the gravel, however, some populations utilize stream areas for rearing and migrate to sea soon after emergence. Anadromous sockeye may spend from one to four years in the ocean before returning to fresh water to spawn and die in late summer and fall.

The adaptations of sockeye salmon to lake environments appear to require more precise homing to spawning areas, both as to time and location than is found in the other species of Pacific salmon. Although available spawning localities are more restricted because of the usual requirement of a lake rearing environment for the juveniles, the overall success of this adaptation is indicated by the fact that sockeye are much more abundant than chinook (*O. tshawytscha*) and coho salmon (*O. kisutch*), which utilize stream rearing environments as juveniles. Juvenile sockeye salmon in fresh water do not need the territorial stream behavior displayed by juvenile chinook and coho salmon, but do exhibit schooling tendencies more characteristic of pelagic feeding fishes.

Other distinctions of sockeye salmon include growth rate and size at maturity. Sockeye do not exhibit the rapid marine growth of coho or pink salmon (*O. gorbuscha*) which mature and return to fresh water after a single winter in the ocean, or of chinook or chum salmon (*O. keta*) which attain a much larger average size at maturity. The flesh of sockeye is a darker red than that of the other salmon species, a color long considered to be a marketing attribute of the canned and, more recently, the fresh or fresh-frozen product.

<u>Fisheries</u>

Sockeye salmon are an important component, and often the most lucrative fishery for Pacific salmon. Coastal fisheries for sockeye salmon presently occur in North America (Canada and the United States) and Asia (Japan and Russia) with major fisheries in all areas except Japan. From 1920 through 1945, sockeye salmon were caught on the high seas by a Japanese mother ship fishery. This fishery started again in 1953 and a land based driftnet fishery moved sufficiently offshore to begin substantial catches of sockeye in 1958. Restrictions in fishing areas resulting from renegotiation of international fishery treaties ended the high seas fisheries in the mid 1980s. In recent years, about 22% of the numbers and 28% by weight of all salmon caught commercially in the North Pacific Ocean and adjacent waters were sockeye. Catches in North America, primarily Alaska and British Columbia, have always been greater than Asian catches. North American catches averaged about 30 million through 1940, declined to 10-15 million in the early 1960s and surged to 40 million and more in the 1990s. The recent record high catches resulted primarily from an increase in run magnitudes of natural stocks in central and western Alaska. Historically, Asian catches of sockeye salmon have averaged fewer than 10 million fish. Most sockeye salmon in the U.S. are caught in Alaska where major fisheries occur in Southeast, central and westward areas. In Alaska, sockeye fisheries occur primarily within State territorial seas (inside 3-miles).

Sockeye salmon catches have been at historic records in Alaska over the past decade with catches exceeding 60 million fish in several years. Most sockeye salmon in Alaska are caught by set and drift gill net fisheries. Recreational fisheries in Alaska usually harvest between 200 and 400 thousand sockeye salmon annually, mostly in river system of the Kenai Peninsula in central Alaska. Subsistence catches of sockeye salmon are not universally maintained, but the catches are important, particularly to native people in a number of localities. The Fraser River Indian tribes recorded annual subsistence catches for the years 1970-82 of 240,000. The subsistence catch of sockeye salmon in the United States was 315,000 in 1993, and over 307,000 was caught in Alaskan waters.

Gill net fisheries for sockeye salmon have some bycatch associated with them, primarily other salmon. The most important bycatch issue is in the southeastern region where younger marine-age chinook salmon, similar in size to sockeye, are caught in sockeye net fisheries. The total harvest of chinook salmon in this region is controlled by quotas under auspices of the Pacific Salmon Treaty. The Alaska Board of Fisheries allocates a portion of the quota for chinook salmon as an allowable bycatch in gill net fisheries.

Measured marine survivals of sockeye salmon, from entry of smolts into stream mouth estuaries to returning adults, have ranged from about 5% to over 50%. Scientists, in general, believe that much of the natural mortality of sockeye salmon juveniles in the marine environment occurs within the first few months, and in probably influenced by three factors of unknown relative importance: (1) size and age at seaward migration; (2) timing of entry into the marine environment; and (3) length of stay in the ocean. Variations in oceanographic conditions and in marine predator populations (fish, mammals and birds) undoubtedly have affected the marine survival of sockeye populations in different ways around the North Pacific rim, but these effects are poorly understood.

Relevant Trophic Information

Sockeye salmon eggs, alevins, and juveniles in freshwater streams and lake systems provide an important nutrient and food source for aquatic invertebrates, other fishes, birds and small mammals. In the marine environment sockeye salmon juveniles are food for many other fishes and coastal sea birds. Adult sockeye salmon are known to be eaten by marine mammals and sharks.

Millions of sockeye salmon adults returning to spawn in thousands of streams through out Alaska provide significant nutrient input into the trophic level of these coastal watersheds. Adult sockeye salmon in streams are major food sources for gulls, eagles, and other birds, along with bear, otter, mink and other mammals.

Describe any potential gear impacts on the habitats of this or other species.

Because sockeye salmon are primarily caught in gill nets there are no known gear impacts to the habitats where these fisheries occur.

What is the approximate upper size limit of juvenile fish (in cm)? Roughly 25 cm.

Provide source (agency, name and phone number or literature reference for any possible additional distribution data.

Karl Hofmeister, Alaska Department of Fish and Game, 907-465-4250
Andy MacGregor, Alaska Department of Fish and Game, 907-465-4224
David Barto, Alaska Department of Fish and Game, 907-465-4268

Habitat and Biological Associations (if known) Narrative

Eggs and Spawning: Sockeye salmon generally spawn in late summer and autumn. Within this period, time of spawning for different stocks can vary greatly, apparently because of adaptations to the most favorable survival conditions for spawning, egg and alevin incubation, emergence, and subsequent juvenile feeding. Although timing of spawning varies little from year to year within a specific spawning area, there are great differences in timing among spawning areas. The timing of spawning appears to be dependent to some degree on the temperature regimen in the gravel where the eggs are incubated. This varies distinctly among spawning area types. In the Bristol Bay region of Alaska, spawning begins in late July in the smaller streams, in early to mid-August in the tributaries of some lakes, and in late August to mid-September in most lake beach areas. In Lake Kuril and its tributaries spawning continues from the end of June until early February with the main spawning occurring from September to November.

Among the species of Pacific salmon, the sockeye salmon exhibits the greatest diversity in adaptation to a wide variety of spawning habitats. The selection of habitats and timing of spawning by a sockeye stock are linked to success of survival, not only during spawning and incubation of the eggs and alevins, but also in the chain of freshwater and marine environments to which the progeny are subsequently exposed. In most instances, but not all, the subsequent environment of the juveniles is a lake or lake chain, and the behavior of the juveniles after emergence depends on the location of the spawning area in relation to the lake rearing area to be utilized. Lake-beach spawning has been recorded in most sockeye lake systems, and is apparently important habitat. Sockeye are also known to spawn in areas which lack lake rearing habitat. These “river spawning” or “sea type” sockeye lay their eggs in river systems with no lake, and emergent fry apparently feed in the stream or low-salinity estuaries for several months before migrating to offshore ocean areas. The circumstances surrounding the initial establishment of a spawning colony and the subsequent adaptive behavior of the progeny can only be surmised. However, the continued use of a specific spawning environment by a sockeye stock depends on the precise homing ability of the species, in which straying to other potential spawning locations is minimal.

The composition of spawning substrate utilized by sockeye salmon varies widely. Some lake-beach spawning occurs to a depth of nearly 30 m in areas of strong upwelling groundwater. In some lakes mass spawning takes place over large angular gravel, too large to be moved by salmon in the normal digging process. The eggs settle in the crevices between the rocks. Generally, however, spawning along lake beaches and in streams takes place in gravel small enough to be readily dislodged by digging, and the digging process tends to remove the silt and clean the gravel where the eggs are deposited. Water depth does not seem to be a critical factor to sockeye in selecting a spawning site. In the small streams and spring ponds it is common to observe pairs of salmon in the spawning process with their dorsal surfaces protruding from the water. In larger rivers, spawning depths are generally not great because riffle areas are preferred. Spawning on lake beaches can extend to considerable depths. It is clear that sockeye can detect upwelling groundwater areas along lake beaches and in spring ponds areas in which to spawn. Generally, the spawning beds are situated in areas with clean gravel, or along the borders between pools and riffles in shallow water with moderate to fast currents. In large rivers, they may spawn in discrete sections of main channels or in tributary channels.

Superimposition is minimized by the territorial defense of the redd by the female following egg deposition, which protects the redd for a few days. Female territory is partly a function of spawner density. Estimates of the capacity of streams to support spawning sockeye were based on density of one female/2 m^2. In spawning channels, maximum fry production was achieved at the spawner density of one female/m^2.

Larvae/alevins: Fertilized eggs begin their five- to eight-month period of embryonic development and growth in intragravel interstices. To survive successfully, the eggs, alevins and pre-emergent fry must first be protected from freezing, desiccation, stream bed scouring or shifting, mechanical injury and predators. Water surrounding them must be non-toxic and of sufficient quality and quantity to provide basic requirements of suitable temperatures, adequate supply of oxygen, and removal of waste materials. Collectively, these requirements are, on average, only partially met even under the most favorable natural conditions. Overall freshwater survival of sockeye salmon from egg to advanced alevin and emerged fry, even in highly productive streams, commonly reaches only 10%-20%, and at times is as low as 1%.

Rates of egg development, survival, size of hatched alevins and percentage of deformed fry are related to temperature and oxygen levels during incubation. Temporary low stream temperatures or dissolved oxygen concentrations, however, may be relatively unimportant at some developmental stages, but lethal at others. Generally, low oxygen levels are non-lethal early, but lethal late in development.

Juveniles: Fry emergence apparently begins in early to mid-April in most instances, peaks in early to mid-May, and ends in late May to early June. Newly emerged sockeye salmon fry show a marked negative rheotaxis, and actively swim downstream to lakes. In some lake outlet spawning areas, the emerging fry swim laterally in an attempt to reach the river banks and avoid being swept downstream. The emergence behavior of fry in lakeshore spawning areas has not been reported. It has been suggested that the seasonal timing of sockeye fry emergence, optimizes the timing of dispersal into their feeding habitat, particularly to take advantage of the seasonal peak abundance of zooplankton of appropriate size. It is postulated that fry emerging earlier or later than the optimum may suffer greater mortality, and thus that timing is a response to this selective pressure. The survival value in entering the lake early is to take advantage of feeding in the lake as long as possible during the summer, thus achieving larger size in preparation for spring smoltification. Annual timing of fry migration and its seasonal pattern is a function of the seasonal timing of the adult spawning period, ecological factors within the incubation habitat that affects development rate and alevin behavior, and transit time needed by the fry to reach their feeding habitat.

Upon entering nursery lakes, sockeye fry disperse quickly into their lake feeding areas. Movement of fry into the nursery areas may be direct and immediate, or sequential, the latter involving occupation of intermediate feeding areas for a period of time. The plasticity of response suggests definite racial adaptations to a variety of different environmental conditions. Intermediate feeding and growth can occur along outlet river banks before migration into the nursery lake. In-lake dispersions of fry is probably a mechanism whereby the lake zooplankton is effectively utilized as food for the juvenile fish.

Sockeye salmon juveniles typically spend one or more growing seasons in the limnetic zone of a nursery lake before smoltification. The transition in feeding behavior and diet from the time of emergence of the fry from stream or lakeshore to the time of smoltification takes many forms. In general, it is a shift from dependence on dipteran insects to pelagic zooplankton. The annual growth attained by juvenile sockeye and length of residence in fresh water varies greatly among populations in different lake systems, as well as between years within individual lakes. Factors affecting growth are highly complex and include (1) size and species composition of the food supply; (2) water temperature and thermal stratification of the lake; (3) photoperiod and length of growing season; (4) relative turbidity of the lake and available light intensity in the water column; (5) intra- and interspecific competition; (6) parasitism and disease; (7) feeding behavior of juvenile sockeye to minimize predation; and (8) migratory movements to seek favorable feeding environments. Growth influences durations of stay in fresh water before smoltification, and within many lake populations the larger members of a year class tend to migrate to sea earlier the spring or migrate a year earlier than smaller members. In the more southern systems, smoltification after one year is nearly universal. Size is not strictly the determinant for duration of stay in fresh water, because some populations with very poor freshwater growth in their first year migrate as yearlings, whereas other populations exhibiting good first-year growth migrate predominantly after a second year of growth. Emergent fry of “river spawning” or “sea type” sockeye which spawn in systems lacking lake rearing habitat, feed in the stream or low-salinity estuaries for several months before migrating to offshore ocean areas.

Sockeye fry at the beginning of lake life are between 25 and 31 mm and weigh between 0.1 and 0.2 g. Yearling smolts vary greatly in size; average range 60 to 125 mm and 2.0 to 30.0 g. After a second year of growth in a lake, two-year old smolts often overlap the size range of yearlings, and have been reported at an average of 200 mm and 84.0 g at Hidden Lake in central Alaska. Sea type sockeye smolts are typically the same size as yearling smolts when they migrate to offshore ocean areas.

After smoltification and exodus from natal river systems in spring or early summer, juvenile sockeye enter the marine environment where they reside for one to four years, usually two or three years, before returning to spawn. Depending on the stock, they may reside in the estuarine or nearshore environment before moving into oceanic waters. They are typically distributed in offshore waters by autumn following outmigration. During the initial marine period, yearling sockeye forage actively on a variety of organisms, apparently preferring copepods and insects, but also eating amphipods, euphausiids, and fish larvae when available. Their growth rate is about 0.6 mm/d.

After entering the open sea during their first summer, juvenile sockeye salmon remain in a band relatively close to the coast. Off the outer coast of British Columbia and southeast Alaska, the juveniles are often recorded on the open sea in late June. By July, the fish are found moving northwestward into the Gulf of Alaska. Sampling in the North Pacific has shown that by October juvenile sockeye are still somewhat distributed primarily nearshore. Evidence indicates the northwestward movement up the eastern Pacific rim is followed by a southwestward movement along the Alaska Peninsula. An offshore movement into the

Gulf of Alaska in late autumn or winter is conjectured for the location of age 1 sockeye in early spring.

Adults: Sockeye salmon from different regions differ in growth rate and age and size at maturity. Growth in length is greatest during the first year at sea, and increase in weight is greatest during the second year. Most sockeye spend two to three years feeding in the ocean before their final summer of return. There is substantial variation in size among populations within an age class. In Alaska, the average size of females that had spent 2 years in the ocean ranged from 45 to 54 cm, and of those that had spent 3 years the average ranged from 51 to 60 cm.

References

Atkinson, C.E., T.H. Rose, and T.O. Duncan. 1967. Pacific salmon in the United States, p. 43-223. *In:* Salmon of the North Pacific Ocean. Part IV. Spawning populations of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 23.

Baggerman, B. 1960. Salinity preference, thyroid activity and the seaward migration of four species of Pacific salmon *(Oncorhynchus). J.* Fish. Res. Board Can. 17:295-322.

Bakkala, R.G. 1971. Distribution and migration of immature sockeye salmon taken by U.S. research vessels with gillnets in offshore waters, 1956-67. Int. North Pac. Fish. Comm. Bull. 27:170.

Bergander, F. 1985. Sockeye salmon (*Oncorhynchus nerka)* stock assessment and evaluation in southeastern Alaska, 1982-1983. Alaska Dep. Fish Game ADF&G Tech Rep. 142:27 p.

Bill, D. 1984. 1982 Kwichak River sockeye smolt studies, p. 2-13. In: D.M. Eggers and H.J. Yuen (eds.) 1982 Bristol Bay sockeye salmon smolt studies. Alaska Dep. Fish Game ADF&G Tech Rep. 103.

Birman, I.B. 1960. New information on the marine period of life and the marine fishery of Pacific salmon, p. 151-164. In: Trudy Soveshchaniia po bioligicheskim osnovam okeanicheskovo rybolovostva, 1958. Tr. Soveshch. Iktiol. Komm. Akad. Nauk SSSR 10 (Trans. From Russian; Fish. Res. Board Can. Transl. Ser. 357)

Brannon, E.L. 1965. The influence of physical factors on the development and weight of sockeye salmon embryos and aliveness. Int. Pac. Salmon Fish. Comm. Prog. Rep. 12:26 p.

Brett, J.R., and J.E. Shelbourn. 1975. Growth rate of young sockeye salmon, (*Oncorhynchus nerka)*, in relation to fish size and ration level. J. Fish. Res. Board Can. 32:2103-10

Bugaev, V.F. 1978. Using the structure of zones of converged sclerites on scales as a criterion for differentiation of local groupings of the sockeye salmon, (*Oncorhynchus nerka)*, of the Kamchatka River basin. J. Ichthyol. 18:826-836.

Burgner, R.L. 1991. Life history of sockeye salmon, *Oncorhynchus nerka*, p 3-117 *in* C. Groot and L. Margolis, eds. Pacific salmon life histories. UBC Press, Vancouver

Chernenko, E.V., and G.D. Kurenkov. 1980. Differentiation of the stock of kokanee *Oncorhynchus nerka* (Walbaum) from Kronotsk Lake, p. 11-15. In: S.M. Konovalov (ed.) Populyatsionnaya biologiya I sistematika lososevykh. Db. Rab. Aakad. Nauk SSSR Dal'nev. Nauch. Tsentr. Inst. Biol. Morya 18 (In Russian)

Drucker, B. 1970. Red Salmon studies at Karluk Lake, 1968. U.S. Fish and Wildlife Service, Auke Bay, AK. 55 p.

Ellis, R.J. 1974 Distribution, abundance, and growth of juvenile sockeye salmon, *Oncorhynchus nerka*, and associated species in the Naknek River system, 1961-1964. NOAA Tech Rep. NMFS SSRF-678:53p.

Flagg, L.C., P. Shields, and D.C. Waite. 1985. Sockeye salmon smolt studies, Kasilof River, Alaska 1984. Alaska Dep. Fish Game FRED Rep. 47:43 p.

Foerster, R.E. 1968. The sockeye salmon, *Oncorhynchus nerka*. Bull. Fish. Res. Board Can. 162:422 p.

French, R., H. Bilton, M. Osako, and A. Hartt. 1976. Distribution and origin of sockeye salmon *(Oncorhynchus nerka)* in offshore water of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 34: 113 p.

French, R.R., and R.G. Bakkala. 1974. A new model of ocean migrations of Bristol Bay sockeye salmon. Fish. Bull. (U.S.) 72:589-614.

French, R.R., and J.E. Mason. 1964. Salmon distribution and abundance on the high seas-winter season 1962 and 1963. Int. North Pac. Fish. Comm. Annu. Rep. 1963:131-141.

Fujii, T. 1975. On the relation between the homing migration of the western Alaska sockeye salmon *Oncorhynchus nerka* (Walbaum) and oceanic conditions in the eastern Bering Sea. Mem. Fac, Fish. Hokkaido Univ. 22:99-191.

Fulton, L.A. 1970. Spawning areas and abundance of steelhead trout and coho, sockeye, and chum salmon in the Columbia River basin - past and present. U.S. Nat. Mar. Fish. Ser. Spec. Sci. Rep. Fish. 618:37 p.

Gard, R., and B. Drucker. 1985. Differentiation of subpopulations of sockeye salmon in the Karluk River system. Annu. Rep. School Fish. Sci. Univ. Alaska, Juneau 1983/84:7.

Groot, C., and K. Cooke. 1987. Homing migration of sockeye salmon, *Oncorhynchus nerka*, to the Fraser River. Fish. Bull. (U.S.) 85:455-469.

Hanamura, N. 1966. Sockeye salmon in the far east, p. 1-27. *In:* Salmon of the North Pacific Ocean. Part III. A review of the life history of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 18.

Harris, C. 1987. Catches of North American sockeye salmon *(Oncorhynchus nerka)* by the Japanese high seas salmon fisheries, 1972-1984, p. 458-479. In: H.D. Smith, L. Margolis, and C.C. Wood (eds.). Sockeye salmon *(Oncorhynchus nerka)* population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96.

Hartman, W.L., and R.L. Burgner. 1972. Limnology and fish ecology of sockeye salmon nursery lakes of the world. J. Fish. Res. Board Can. 29:699-715.

Healey, M.C. 1987. The adaptive significance of age and size at maturity in female sockeye salmon *(Oncorhynchus nerka)*, p. 110-117. In: H.D. Smith, L. Margolis, and C.C. Wood (eds.). Sockeye salmon *(Oncorhynchus nerka)* population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96.

Hoag, S.H. 1972. The relationship between the summer food of juvenile sockeye salmon, *Oncorhynchus nerka*, and the standing stock of zooplankton in Iliamna Lake, Alaska. Fish. Bull. (U.S.) 70:355-362.

Huttunen, D.C. 1987. Abundance, age, sex and size of salmon (*Oncorhynchus* sp.) catches and escapements in the Kuskokwim area, 1985. Alaska Dep. Fish Game ADF&G Tech. Data Rep. 212:83 p.

Lander, A.H., and G.K. Tanonaka. 1964. Marine growth of western Alaskan sockeye salmon (*Oncorhynchus nerka* Walbaum). Int. North Pac. Fish. Comm. Bull. 14:1-31.

Lebida, R.C. 1984. Larson Lake sockeye and coho salmon smolt enumeration and sampling, 1982. Alaska Dep. Fish Game FRED Rep. 35:31p.

LeBrasseur, R.J. 1966. Stomach contents of salmon and steelhead trout in the northeastern Pacific Ocean. J. Fish. Res. Board Can. 23:85-100.

Manzer, J.I., T. Ishida, A.E. Peterson, and M.G. Hanavan. 1965. Salmon of the North Pacific Ocean. Part V. Offshore distribution of salmon. Int. North Pac. Fish. Comm. Bull. 15:452 p.

Nelson, J.S. 1968. Distribution and nomenclature of North American kokanee, *Oncorhynchus nerka.* J. Fish. Res. Board Can. 25:409-414.

Olsen, J.C. 1968. Physical environment and egg development in a mainland beach area and an island beach area of Iliamna Lake, p. 169-197. In: R.L. Burgner (ed.). Further studies of Alaska sockeye salmon. Univ. Wash. Publ. Fish. New Ser. 3.

Raleigh, R.F. 1967. Genetic control in the lakeward migrations of sockeye salmon *(Oncorhynchus nerka)* fry. J. FISH. Res. Board Can. 24:2613-2622.

Ricker, W.E. 1962. Comparison of ocean growth and mortality of sockeye salmon during their last two years. J. Fish. Res. Board Can. 19:531-560.

Ricker, W.E. Size and age of British Columbia sockeye salmon (*Oncorhynchus nerka*) in relation to environmental factors and the fishery. Can. Tech. Rep. Fish. Aquat. Sci.1115:32 p.

Rogers, D.E. 1987. The regulation of age at maturity in Wood River sockeye salmon (*Oncorhynchus nerka*), p. 78-89. In: H.D. Smith, L. Margolis, and C.C. Wood (eds.).Sockeye salmon *(Oncorhynchus nerka)* population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96.

Sharr, S. 1983. Catch and escapement statistics for Copper and Bering River sockeye (*Oncorhynchus nerka*), chinook (*O. tshawytscha*), and coho salmon (*O. kisutch*), 1982. Alaska Dep. Fish Game. ADF&G Tech. Data Rep 98:45 p.

Simpson, K., L. Hop Wo, and I. Miki. 1981. Fish surveys of 15 sockeye salmon (*Oncorhynchus nerka*) nursery lakes in British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 1022:87 p.

Straty, R.R. 1974. Ecology and behavior of juvenile sockeye salmon (*Oncorhynchus nerka*), in Bristol Bay and the eastern Bering Sea, p. 285-320. In: D.W. Hood and E.J. Kelley (eds.) Oceanography of the Bering Sea with emphasis on renewable resources. Univ. Alaska Inst. Mar. Sci. Occ. Publ.2

Takeuchi, I. 1972. Food animals collected from the stomachs of three salmonid fishes (*Oncorhynchus*) and their distribution in the natural environments in the northern North Pacific. Bull. Hokkaido Reg. Fish. Res. Lab. 38:119 p.

Wood, C.C., B.E. Riddell, and D.T. Rutherford. 1987. Alternative juvenile life histories of sockeye salmon *Oncorhynchus nerka*) and their contribution to production in the Stikine River, northern British Columbia, p. 12-24. In: H.D. Smith, L. Margolis, and C.C. Wood (eds.).Sockeye salmon *(Oncorhynchus nerka)* population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96.

SPECIES: Sockeye salmon, *Onchorynchus nerka*

Stage - EFH Level	**Duration or Age**	**Diet/Prey**	**Season/ Time**	**Location**	**Water Column**	**Bottom Type**	**Oceano-graphic Features**	**Other**
Eggs and larvae (alevins) EFH level: 1-3	eggs: 90-100 d larvae: 100-125 d	NA	late summer, fall and winter	WC, LK	Intragravel	CB, G	NA	Develop at 1-10°C, eggs hatch about 100 d, alevins emerge from gravel about 125 d post hatch
Juveniles, Freshwater EFH level: 1-4	1 to 3 years, fry emerge and move quickly to lakes, or, rarely, 3-4 mo in estuaries	copepods, bosminids, Daphnia chironomids dipterans, stoneflies	for yearling and older smolt, early to late summer for sea type run	WC, LK EST	P, N	NA	NA	Preference pelagic feeding in lakes, usually not with other fishes, except when predators present
Juveniles, estuarine EFH level: 0-3	1-4 mo	copepods, amphipods,	spring, summer, fall	BCH, EST, to 30 m	P, N	NA	UP, CL	larger fish progressively farther from shore
Juveniles, marine EFH level: 0-2	6-8 mo	copepods, amphipods, small fishes, squid mysids, euphausiids	early summer to late winter	BCH, ICS, MCS, IP BAY	P, N	NA	UP, CL	movements from near-shore to offshore areas

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Adult, immature and maturing, marine EFH level: 0-2	1 - 4 yrs from smolt to mature adult	copepods, amphipods, insects, small fishes, squid	immature: year round 1-3 yr	BCH, ICS, MCS, OCS, USP, LSP, BSN, BAY, IP	P, N	NA	UP	migration timing for different regional stock groups varies; earlier in the north, later in the south
Adults, freshwater EFH level: 1-3	2 - 4 mo	no active feeding in freshwater	Spawning migration (May-August)	WC, LK	depth in streams <10 cm, depth in lakes to 20 m	CB, G	NA	migration timing for different regional stock groups varies; earlier in the north, later in the south

Abbreviations used in table:

EFH Level: Range indicates levels in different regions of Alaska: 0) No systematic sampling has been conducted for this species and life stage; may have been caught opportunistically in small numbers during other surveys; 1) Presence/absence distribution data are available for some or all portions of the geographic range; 2) Habitat-related densities are available; 3) Habitat-related growth, reproduction, or survival rates are available; 4) Habitat-related production rates are available.
Location: WC = water courses, rivers, streams, sloughs; LK = lakes, ponds (some are temporary); BCH = beach (intertidal); EST = estuarine, intermediate salinity, nearshore bays with inlet watercourses, eelgrass and kelp beds; ICS = inner continental shelf (1-50 m deep); MCS = middle continental shelf (1-100 m deep); OCS = outer continental shelf (1-200 m); BAY = nearshore bays (e.g., fjords); IP = island passes (areas of high current).
Water Column: P = pelagic (found off bottom, not necessarily associated with a particular bottom type); N = neustonic (found near surface).
Bottom Type: G = gravel; K = kelp; SAV = subaquatic vegetation (e.g., eelgrass).
Oceanographic/Riverine Features: UP = upwelling; G = gyres; F = fronts; CL = thermo- or pycnocline; E = edges.
General: U = Unknown; NA = not applicable

See table of contents for the following figures:

Figure 1. Coastal and spawning distributions of sockeye salmon; stippled areas show the primary distribution and hatched areas show the limited occurrence. (Figure from Burgner 1991).

Figure 2. Overall ocean distribution of sockeye salmon. Stippled areas show where sockeye salmon were caught in INPFC salmon research operations; zeros show areas where sampling was conducted but sockeye were not caught; hatched areas show where sockeye are known or strongly suspected to occur on the basis of distributions of spawning runs, or miscellaneous nearshore studies. (Figure from Burgner 1991)

Figure 3. Marine EFH for sockeye salmon: the general distribution and areas of known concentration of immature and maturing sockeye salmon to the limits of the US EEZ off Alaska. Areas of concentration are based on the migration of Bristol Bay sockeye salmon from the Gulf of Alaska into the Bering Sea through the False Pass/Unimak Island area. Westward areas within the US EEZ not shown on the map are also EFH for sockeye salmon.

Habitat Description for Chinook (King) Salmon
(*Oncorhynchus tshawytscha*)

Management Plan and Area(s): Salmon Fisheries in the EEZ Off the Coast of Alaska, NPFMC, 1990

Life History and General Distribution

Chinook salmon, also called king, spring, or tyee salmon, are the least abundant and largest of the Pacific salmon. They are distinguished from other species of Pacific salmon by their large size, the small black spots on both lobes of the caudal fin, black pigment at the base of the teeth, and a large number of pyloric caeca. The natural freshwater range of the species includes large portions of the Pacific rim of North America and Asia. In North America, chinook salmon historically ranged from the Ventura River in California (~34° latitude) to Kotzebue Sound in Alaska (~66° N); in addition, the species has been identified in North America in the Mackenzie River, which drains into the Arctic Ocean. In Asia, natural populations of chinook salmon have been documented from Hokkaido Island, Japan (~42° N) to the Andyr River in Russia (~64° N). Within this range, the largest rivers tend to support the largest aggregate runs of chinook salmon and have the largest individual spawning populations. Major rivers near the southern and northern extremes of the range support populations of chinook salmon comparable to those near the middle of the range. For example, in North America, the Yukon River near the north edge of the range and the Sacramento-San Joaquin River system near the south edge of the range have historically supported chinook salmon runs comparable to those of the Columbia River and the Fraser River, which are near the center of the species range along this Pacific coast.

In marine environments, chinook salmon range widely throughout the North Pacific Ocean and the Bering Sea, from 38° latitude. The southern edge of the marine distribution expands and contracts seasonally and between years depending on ocean temperature patterns. While the marine distribution of chinook salmon can be highly variable even within a population, there are general migration and ocean distribution patterns characteristic of populations in specific geographic areas. For example, chinook salmon that spawn in rivers from the Rogue River in Oregon south to California disperse and rear in oceanic waters off the Oregon and California Coast, whereas those that spawn north of the Rogue River to southeastern Alaska migrate north and westward along the Pacific coast. These migration patterns are of particular interest for the management of chinook salmon in the EEZ off Alaska, as they result in the harvest of fish from Oregon, Washington, British Columbia, and Alaska within the management zone.

Pacific salmon have a generalized life history that includes the incubation and hatching of embryos and emergence and initial rearing of juveniles in freshwater; migration to oceanic habitats for extended periods of feeding and growth; and return to natal waters for completion of maturation, spawning, and death. Within this general life history strategy, chinook salmon display diverse and complex life history patterns and tactics. Their spawning environments range from just above tidewater to over 3,200 km from the ocean, from coastal rainforest streams to arid mountain tributaries at elevations over 1,500 m. At least 16 age categories of mature chinook salmon have been documented, involving 3 possible freshwater ages and total ages of 2-8 years, reflecting the high variability within and among populations in length of freshwater, estuarine, and oceanic residency. Chinook salmon also demonstrate variable ocean migration patterns and timing of spawning migrations.

This variation in life history strategy has been explained by separating chinook salmon into two races: stream- and ocean-type fish. Stream-type fish have long freshwater residence as juveniles (1-2 years), migrate rapidly to oceanic habitats, enter freshwater as immature or "bright" fish, and spawn far upriver in late summer or early fall. Ocean-type fish have short, highly variable freshwater residency (from a few days to 1 year), extensive estuarine residency, enter fresh-water at a more advanced state of maturity, and spawn within a few weeks of freshwater entry in the lower portions of the watershed. Within these two types, there is also substantial variability due to a combination of phenotypic plasticity and genetic selection to local conditions. For example, adult run-timing is strongly influenced by in-river flow volumes and temperature levels.

Chinook salmon have distinctly different feeding habits and distribution and in ocean habitats than do other species of Pacific salmon. Chinook salmon are the most piscivorous of the Pacific salmon, and are also distributed deeper in the water column. While other species of salmon generally are surface oriented, utilizing primarily the upper 20 m, chinook salmon tend to be at greater depths and are often associated with bottom topography. Because of their distribution in the water column, the majority of chinook salmon harvested in commercial troll fisheries are caught at depths of 30 m or greater, and chinook salmon is the most common salmon species taken as bycatch in mid-water and bottom trawl fisheries.

Declines in the abundance of chinook salmon have been well documented throughout the southern portion of the range. Concern over coast-wide declines from southeastern Alaska to the Pacific Northwest was a major factor leading to the signing of the Pacific Salmon Treaty between the United States and Canada in 1985. Wild chinook salmon populations have been extirpated from large portions of their historic range in a number of watersheds in California, Oregon, Washington, Idaho, and southern British Columbia, and a number of Evolutionarily Significant Units (ESUs) have been listed by National Marine Fisheries Service as at risk of extinction under the Endangered Species Act (ESA). Habitat degradation is the major cause for extinction of populations; most are related to dam construction. Urbanization, agricultural land use and water diversion, and logging are also factors contributing to habitat degradation and the decline of chinook salmon. The development of large-scale hatchery programs, have, to some degree, mitigated the decline in abundance of chinook in some areas. However, genetic and ecological interactions of hatchery and wild fish have also been identified as risk factors for wild populations, and the high harvest rates directed at hatchery fish may cause over-exploitation of co-mingled wild populations.

Fisheries

Because of their large size and excellent palatability, chinook salmon are highly prized by commercial, sport, and subsistence fishers. In Alaska, approximately 1 million chinook salmon are harvested annually. While this is less than 1% of the annual salmon catch in the State, chinook salmon typically are the focus of a disproportionately larger amount of management and regulatory effort because of the conservation concerns and intense allocation issues for this species.

In most of the State, there is no directed harvest of chinook salmon in the EEZ. Most fishing effort takes place in the coastal or riverine waters of the State. The FMP for salmon in the Alaska EEZ prohibits commercial harvest in the EEZ, with a few exceptions. The most notable exception is the commercial troll harvest off of southeast Alaska. While much of this fishery is also in State waters, it has been traditionally managed since Alaska statehood (1959) with little recognition of the boundary separating State and Federal waters. Chinook and coho salmon are the primary target species of this hook-and-line fishery.

The commercial troll fishery for chinook salmon in southeast Alaska developed in the early 1900s. The fishery occurred all year with no overall catch limits. Peak harvests of chinook were in the 1930s, when annual catch averaged over 600,000. Concurrent with the development of the Columbia River hydroelectric dams, catches declined to average 250,000-350,000 chinook annually. Beginning in 1978, the Alaska Department of Fish and Game (ADFG) and the North Pacific Fishery Management Council (NPFMC) set harvest limits for the fishery in the first FMP for salmon in Alaska. These limits were initially a harvest range of 286,000-320,000 chinook salmon for the Southeast Alaska troll fishery. The FMP also banned commercial salmon fishing in the EEZ west of 175° E longitude, banned fishing for salmon with nets throughout the EEZ (with a few specific exceptions), and imposed time closures on commercial trolling in the EEZ east of 175°.

These harvest ranges became part of a 15-year stock rebuilding program begun in 1981 for stocks that spawn in southeast Alaska and in transboundary rivers that originate in Canada and flow through southeast Alaska. In 1985, the Pacific Salmon Treaty between the U.S. and Canada included specific provisions for rebuilding chinook salmon stocks coast-wide. The Chinook Annex to the treaty established specific total catch limits for chinook in Southeast Alaska and in certain fisheries in British Columbia in 1985 and 1986; subsequently, the catch limits were to be negotiated annually. The catch ceiling in southeast Alaska was originally established at 263,000 "treaty fish", with a provision for additional harvest of fish produced by new enhancement operations in the region. The catch ceiling included an allocation for incidental catch of chinook salmon in net fisheries directed at other salmon species, as well as the commercial and recreational troll harvests. It resulted in a reduction of approximately 100,000 chinook in the commercial troll fishery relative to its average catches over the prior two decades.

In 1990, the NPFMC revised the salmon FMP to reduce redundant regulation of the salmon fisheries in the EEZ with ADFG and the Pacific Salmon Commission (PSC). While recognizing that the salmon fisheries require Federal participation and oversight stipulated in the Magnuson Act, the NPFMC deferred setting harvest levels to ADFG and the PSC, and regulation of the sport and commercial fishery to ADFG providing the harvest levels and allocations are consistent with NPFMC goals and objectives stated in the FMP and the National Standards of the Magnuson Act. To date, the NPFMC has not exercised its option of specifying management measures in the EEZ that differ from State regulation.

Management and catch limits in the southeast Alaska chinook salmon fishery have continued to be a contentious issue. While chinook salmon spawning in southeast Alaska and the transboundary rivers have been generally stable or increasing in abundance since the establishment of the PSC management regime, abundance of many wild populations of chinook salmon in British Columbia and the Pacific Northwest have not recovered or have continued to decline. Fixed harvest levels were formulated to result in decreasing exploitation rates of chinook salmon in mixed-stock fisheries: as wild stocks rebuilt and enhancement activities increased, general abundance of chinook salmon in the mixed-stock fisheries, in concert with catch ceilings, would result in a lower proportion harvested by these fisheries. In the first few years after the Treaty, this concept seemed reasonable, but poor survivals due to ocean conditions in the early 1990s resulted in declining abundances in the ocean fisheries, so that fixed harvest levels result in increasing exploitation. Due to this and other allocation and conservation concerns, there has been no agreement on catch ceilings within the PSC since 1993. In 1995, ADFG proposed a management regime based on the estimated abundance of chinook salmon. ADFG implemented this abundance-based management approach in 1995, but tribal groups and the state management agencies in the Pacific Northwest sued successfully for the closure of the fishery in August of 1995. In 1996, the fishery reopened with a management ceiling agreed to by the U.S. Commissioners (which represent both Alaska and Pacific Northwest interests) to the PSC. In 1997, the U.S. Commissioners agreed to apply an abundance-based management approach using a modified version of the original ADFG proposal. The agreement calls for setting preseason catch targets based on the forecasts made by the Chinook Technical Committee (CTC) of the PSC, then refining these preseason forecasts using catch per unit effort data from the summer troll fishery. This agreement has been implemented by ADFG in 1997, but has not been agreed to by Canada in the PSC process.

Because fish from chinook salmon ESUs that have been listed as threatened or endangered occur in the southeast Alaska troll fishery, NMFS reviews the fishery under Section 7 of the ESA and, in association with the Biological Opinion, issues an incidental take statement that covers the ESA listed fish that are inadvertently and unknowingly taken in the fishery. The biological assessment has found that the take of listed ESUs in the fishery has been incidental to other stocks and a small percentage of the total mortality, either on a single year or cohort basis. To date, NMFS has found that this fishery is not likely to jeopardize the continued existence or recovery of ESA listed species.

Chinook salmon fisheries in Alaska have some bycatch associated with them. Generally, the numbers of other species taken during directed chinook fishing is small and not considered a conservation issue. The most important bycatch issue in the commercial and recreational hook-and-line fisheries is the capture of undersized chinook salmon which must be released. While the majority of these fish survive the hooking encounter, large numbers can be hooked and substantial mortality incurred. The Pacific Salmon Treaty requires accounting for the degree of such bycatch mortality, and the CTC uses this information in modeling the status and abundance of component stocks.

Relevant Trophic Information

Chinook salmon eggs, alevins, and juveniles in freshwater streams provide an important nutrient input and food source for aquatic invertebrates, other fishes, birds and small mammals. The carcasses of chinook adults can also be an important nutrient input in their natal watersheds, as well as providing food sources for terrestrial mammals such as bears, otters, and minks, and birds such as gulls, eagles, and ravens. Because of their relatively low abundance in coastal and oceanic waters, chinook salmon in the marine environment are typically only an incidental food item in the diet of other fishes, marine mammals, and coastal sea birds.

Potential gear impacts on the habitats of this or other species:

Directed fisheries of chinook salmon in Alaska include marine commercial and recreational hook-and-line fisheries; marine commercial gill-net and seine fisheries; and estuarine and riverine gill-net (both set-net and drift), recreational, personal use, and subsistence fisheries. Two types of impacts can occur: (1) direct effects of the gear to habitat; and (2) bycatch or entanglement of non-target species. In the marine fisheries, direct impact of the gear to marine habitats is limited, but some localized effects can occur, such as trolling weights damaging coral or purse seines damaging kelp beds or benthic structure. Because these types of impacts also endanger the gear itself, they are typically self-limiting. Bycatch and entanglement of non-target species can occur in the marine fisheries, such as bycatch of demersal rockfish in hook-and-line fisheries, and entanglement of seabirds and marine mammals in net fisheries. In the estuarine and riverine fisheries, direct impact to riparian vegetation and channel morphology can occur from the shore-based fishing gears, such as set-nets and recreational fishing. Where use levels are high, this type of impact can be sufficient to require restoration management initiatives. An example is the Kenai River restoration work needed to repair damage from recreational fishing for chinook salmon and other salmonids.

Upper size limit of juvenile fish (in cm):

71 CM TOTAL LENGTH. This is the regulatory minimum harvest size used in the Alaska hook-and-line fisheries in order to minimize catches of immature fish. However, because chinook salmon can mature at ages of 2-8 total years, the term “juvenile” is better defined by physiological progress of maturation rather than a threshold size.

Sources for additional distribution data:

Dave Gaudet , Alaska Department of Fish and Game, 907-465-4250
William Heard, NMFS, Auke Bay Laboratory, 907-789-6003

Habitat and Biological Associations:

As noted above, chinook salmon occur over abroad geographic range, encompassing different ecotypes and very diverse habitats. Across the geographic range which the species has colonized, populations of chinook salmon have developed localized adaptations to site specific characteristics. These local adaptations result in different and diverse characteristics of biological importance, including timing of spawning, adult and juvenile migration timing, age and size at maturity, duration of freshwater residency, and ocean distribution. Chinook salmon have been studied and managed intensively for decades. There is a large body of literature describing their biology and ecology. But for freshwater habitats, habitat specific information for chinook salmon in particular watersheds is sparse, especially in the northern portion of the range, and for estuarine and marine habitats, there is little data beyond presence/absence or density information. The range in the amount of habitat specific information by life-history stage is reflected in the information levels assigned the different life-history stages. EFH is defined for this species on the basis of watershed-specific information available about the species' distribution, and its known range of marine distribution within the EEZ.

Eggs and Spawning: Chinook salmon spawn in a broad range of habitats. They have been known to spawn in water ranging from a few centimeters deep to several meters deep, and in channel widths ranging from small tributaries 2-3 m wide to the main-stems of large rivers such as the Columbia and Sacramento. Typically, redd (nest) size is 5-15 m^2, and water velocities are 40-60 cm/sec. The depth of the redd is inversely related to water velocity; generally the female buries her eggs in clean gravel, 20-36 cm deep. Because of their large size, chinook salmon are able to spawn in higher water velocities and utilize coarser substrates than other salmon species. In general, female chinook salmon select sections of the spawning stream with high subgravel flow. Because their eggs are the largest of the Pacific salmon, with a correspondingly small surface-volume ratio, they may be more sensitive to reduced oxygen levels and require a higher rate of irrigation. Fertilization of the eggs occurs simultaneous with deposition. Males compete for the right to breed with a spawning females. Chinook females remain on their redds 6-25 days after spawning, defending the area from superimposition of eggs from another female.

Larvae/alevins: Fertilized eggs begin their five- to eight-month period of embryonic development and growth in intragravel interstices. To survive successfully, the eggs, alevins and pre-emergent fry must first be protected from freezing, desiccation, stream bed scouring or shifting, mechanical injury and predators. Water surrounding them must be non-toxic and of sufficient quality and quantity to provide basic requirements of suitable temperatures, adequate supply of oxygen, and removal of waste materials. Rates of egg development, survival, size of hatched alevins and percentage of deformed fry are related to temperature and oxygen levels during incubation. Generally, low oxygen levels are non-lethal early, but lethal late in development. Under natural conditions, 30% or less of the eggs survive to emerge from the gravel as fry.

Juveniles: Chinook salmon are typically 33-36 mm in length when they emerge from the incubation gravel. Residency in freshwater and size and timing of seawater migration are highly variable. Ocean-type fish can migrate seaward immediately after yolk absorption. The majority of ocean-type fish migrate at 30-90 days after emergence, but some fish move seaward as fingerlings in the late summer of their first year, while others overwinter and migrate as yearling fish. Stream-type fish, in contrast, generally spend at least one year in freshwater, migrating as one- or two-year old fish. In Alaska, the stream-type life history predominates although ocean-type life histories have been documented in a few Alaska watersheds. Water and habitat quality and quantity determine the productivity of a watershed for chinook salmon. Both stream- and ocean-type fish utilize a wide variety of habitats during their freshwater residency, and are dependent on the quality of the entire watershed, from headwater to salt water. The stream/river ecosystem must provide adequate rearing habitat, and migration corridors from spawning and rearing areas to the sea. Stream-type juveniles are more dependent on freshwater ecosystems because of their extended residence in these areas. The principal foods in freshwater are larval and adult insects. The seaward migration of smolts is timed so that the smolts arrive in the estuary when food is plentiful. Migration and rearing habitats overlap. Stream flows during the migratory period tend to be high, which facilitates seaward movement and provides some sheltering from predation.

After entering saltwater, chinook juveniles disperse to oceanic feeding areas. Ocean-type fish have more extended estuarine residency, tend to be more coastal oriented, and do not generally migrate as far as stream-type fish. Food in estuarine areas include epibenthic organisms, insects, and zooplankton.

Adults: Chinook salmon typically remain at sea for 1 to 6 years. They have been found in oceanic waters at temperatures ranging from 1-15° C. They do not concentrate at the surface as do other Pacific salmon, but are most abundant at depths of 30-70 m. Fish make up the largest component of their diet at sea, although squid, pelagic amphipods, copepods, and euphausiids are also important at times.

Ocean distribution patterns have been shown to be influenced by both genetics and environmental factors. Migratory patterns in the ocean may have evolved as a balance between the benefits of accessing specific feeding grounds and the energy expenditure and dispersion risks necessary to reach them. Along the eastern Pacific rim, chinook salmon originating north of Cape Blanco on the Oregon coast tend to migrate north towards and into the Gulf of Alaska, while those originating south of Cape Blanco migrate south and west into waters off Oregon and California. As a result, chinook salmon that occur in the EEZ fishery in Alaska originate from the Oregon coast to southeast Alaska. Not all stocks within this large geographic area are distributed into the southeast Alaska fishery, however. For example, Puget Sound stocks do not normally migrate that far north.

Habitat Concerns

Habitat loss and alteration have reduced, and in some cases, extirpated chinook salmon over a large portion of their range. Losses of chinook habitat have occurred as a result of other resource development, such as hydroelectric power and logging, agriculture, and urbanization. Most habitat loss has occurred in freshwater ecosystems that support chinook salmon development; estuarine rearing areas have also been affected in some areas by industrial development, urbanization, and dredging. The oceanic environment of chinook salmon is considered largely unchanged by anthropogenic activities, although offshore petroleum production and local, transitory pollution events such as oil spills do pose some degree of risk.

Offshore petroleum production and large-scale transport of petroleum occurs in the Alaska EEZ, although at this time there is no offshore production of petroleum in the commercial troll area of the EEZ. Offshore oil and gas development and transport will inevitably result in some oil entering the environment at levels exceeding background amounts. The *Exxon Valdez* oil spill was shown to have direct effects on the survival and habitats of pink salmon. Chinook salmon were not directly affected, because of their different habitat utilization in the spill area. In general, the early life history stages of fish are more susceptible to oil pollution than juveniles or adults.

By far, the most serious habitat concern for chinook salmon is the degradation of the freshwater watersheds that support those stages of their life history. Dams and impoundments for hydroelectric power and water diversion have caused large-scale extirpation of chinook salmon in the Pacific Northwest by eliminating access to anadromous fish, and have altered the spawning, rearing, and migration corridors of chinook salmon in many watersheds. There are presently no dams in place or in planning that would block rivers used by chinook salmon in Alaska. However, because many chinook salmon harvested under the FMP for Alaska originate in the Pacific Northwest, these types of habitat impacts in other regions directly affect the Alaska fishery.

Logging and associated road construction has resulted in degraded habitat by causing increased erosion and sedimentation, changes in temperature regimes, and changes in seasonal flow patterns. Timber harvest has been a major resource use in Southeast Alaska, and is increasing in southcentral Alaska. Timber harvest in the Pacific Northwest and British Columbia also impacts the Alaska fishery because of the presence of stocks from these regions in the Alaska EEZ.

Placer mining has caused serious degradation of chinook habitats in some river systems, especially in Yukon River drainages. While these impacts are of concern, most of the stocks directly affected do not migrate into the chinook fishery managed under the FMP.

Urbanization and coastal development can have pronounced effects on coastal ecosystems, particularly estuaries, through modification of the hydrography, biology, and chemistry in the developed area. Increased nutrient input, filling of productive wetlands, and influx of contaminants commonly occur with coastal development. These impacts can reduce or eliminate rearing potential for juvenile chinook salmon. Increased levels of coastal development in Alaska as well as in the Pacific Northwest and British Columbia can be expected.

There is a definite south-north cline to the degree of habitat degradation and the status of chinook populations in the eastern Pacific. Habitat degradation in Alaska is certainly a management concern, but to date has not had the degree of impacts on chinook populations as in the Pacific Northwest. In southeast Alaska, logging is considered the largest potential threat to anadromous fish habitat. Relatively little logging has occurred, however, in watersheds supporting chinook salmon in the region. However, because of the stock composition of the fish harvested in the EEZ of southeast Alaska, freshwater ecosystems in the Pacific Northwest represent essential fish habitat for sustaining the diversity and abundance of chinook salmon in the Alaska EEZ.

References:

Alderdice, D.F., and F.P.J. Velsen. 1978. Relation between temperature and incubation time for eggs of chinook salmon *(Oncorhynchus tshawytscha).* J. Fish. Res. Board Can. 35:69-75.

Alderdice, D.F., W.P. Wickett, and J.R. Brett. 1958. Some effects of temporary exposure to low dissolved oxygen levels on Pacific salmon eggs. J. Fish. Res. Board Can. 15:229-249.

Atkinson, C.E., T.H. Rose, and T.O. Duncan. 1967. Pacific salmon in the United States, p. 43-223. *In:* Salmon of the North Pacific Ocean. Part IV. Spawning populations of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 23.

Baker, T.T., A.C. Wertheimer, R.D. Burkett, R. Dunlap, D.M. Eggers, E.I. Fritts, A.J. Gharrett, R.A. Holmes, and R.L. Wilmot. 1996. Status of Pacific salmon and steelhead escapements in southeastern Alaska. Fisheries 21(10): 6-19.

Fiscus, C.H. 1980. Marine mammal-salmonid interactions: a review. P. 121-132. *In:* W. J. McNeil and D. C. Himsworth (eds.). Salmonid ecosystems of the North Pacific. Oregon State University Press, Corvallis, OR.

Gharrett, A.J., S.M. Shirley, and G.R. Tromble. 1987. Genetic relationships among populations of Alaskan chinook salmon. Canadian Journal Fish. Aquat. Sci. 44:765-774.

Hartt, A.C. 1966. Migrations of salmon in the North Pacific Ocean and Bering Sea as determined by seining and tagging, 1959-1960. Int. North Pac. Fish. Comm. Bull. 19: 141p.

Hartt, A.C., and M.B. Dell. 1986. Early oceanic migrations and growth of juvenile Pacific salmon and steelhead trout. Int. North Pac. Fish. Comm. Bull. 46: 105p.

Healey, M.C. 1980. The ecology of juvenile salmon in Georgia Strait, British Columbia. Pages 203-229 *in* W. J. McNeil and D.C. Hinsworth (eds.), Salmonid ecosystems of the North Pacific. Oregon State University Press, Corvallis, Or.

Healey, M.C. 1983. Coast-wide distribution and ocean migration patterns of stream-type and ocean-type chinook salmon. Canadian Field-Naturalist 97:427-433.

Healey, M.C. 1991. Life history of chinook salmon, *Oncorhynchus tshawytscha*, p 311-394 *in* C. Groot and L. Margolis (eds.), Pacific salmon life histories. UBC Press, Vancouver

Heard, W.R., R. Burkett, F. Thrower, and S. McGee. 1995. A review of chinook salmon resources in southeast Alaska and development of an enhancement program designed for minimal hatchery-wild stock interactions. Amer. Fish. Soc. Symposium 15: 21-37.

Major, R.L., J. Ito, S. Ito, and H. Godfrey. 1978. Distribution and origin of chinook salmon in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 38:54p.

Mathews, G.M., and R.S. Waples. Status review for Snake River spring and summer chinook salmon. NOAA Tech. Memo. NMFS F/NWC-200.

Meacham, C.P., and J.H. Clark. 1994. Pacific salmon management - the view from Alaska. Alaska Fishery Research Bulletin 1(1): 76-80.

McIsaac, D.O., and T.P. Quinn. 1988. Evidence for a hereditary component in homing behavior of chinook salmon (*Oncorhynchus tshawytscha*). Can. Journal Fish. Aquat. Sci. 45: 2201-2205.

Nehlson, W., J.E. Williams, and J.A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

NPFMC. 1990. Fishery management plan for the salmon fisheries in the EEZ off the coast of Alaska. North Pacific Fishery Management Council, Anchorage, AK.

Pacific Salmon Commission. 1994. Joint Chinook Technical Committee 1993 Annual Report. Pacific Salmon Commission Report TCCHINOOK 94-1. Vancouver, British Columbia.

Pearcy, W. 1992. Ocean ecology of North Pacific salmonids. Univ. Wash. Press, Seattle, WA.

Orsi, J.A., and H.W. Jaenicke. 1996. Marine distribution and origin of prerecruit chinook salmon, *Oncorhynchus tshawytscha*, in southeastern Alaska. Fish. Bull. 94: 482-497.

Orsi, J.A., and A.C. Wertheimer. 1995. Marine vertical distribution of juvenile chinook and coho salmon in southeastern Alaska. Tran. Amer. Fish. Soc. 124: 159-169.

Rigby, P., J. McConnaughey, and H. Savikko. 1991 . Alaska Commercial Salmon Fisheries, 1878-1991. Alaska Department of Fish and Game Regional Information Report 5J91-16.

Roni, P., and T.P. Quinn. 1995. Geographic variation in size and age of North American chinook salmon. N. Am. J. Fish. Manag. 15: 325-345.

Taylor, E.B. 1990. Environmental correlates of life-history variation in juvenile chinook salmon, *Oncorhynchus tshawytscha*. J, Fish. Biol. 31: 1-17.

Utter, F., G. Milner, G. Stahl, and D. Teel. 1989. Genetic population structure of the chinook salmon, *Oncorhynchus tshawytscha*, in the Pacific northwest. Fish. Bull. 87: 239-264.

Waples, R.S., J.R.P. Jones, B.R. Beckman, and G.A. Swan. 1991. Status review for Snake River fall chinook salmon. NOAA Tech. Memo. NMFS F/NWC-201.

Wertheimer, A.C. 1996. The status of Alaska salmon. Pages 179-197 *In* D. J. Stouder, P.A. Bisson, and R.J. Naiman (eds), Pacific salmon and their ecosystems: status and future options. Proceedings of a Symposium, Seattle, Washington, Jan. 10-12, 1994. Chapman Hall, New York.

Wertheimer, A.C., and A.G. Celewycz. 1996. Abundance and growth of juvenile pink salmon in oiled and non-oiled locations of western Prince William Sound after the *Exxon Valdez* oil spill. Pp.518-532. *In* S.D. Rice, R.B. Spies, D.A. Wolfe, and B.A. Wright (Eds.). *Exxon Valdez* Oil Spill Symposium Proceedings. American Fisheries Society Symposium Number 18.

Chinook salmon, *Oncorhynchus tshawytscha*

Stage - EFH Level	**Duration or Age**	**Diet/Prey**	**Season/Time**	**Location**	**Water Column**	**Bottom Type**	**Oceano-graphic/ Riverine Features**	**Other**
Eggs and larvae (alevins) 1-2	50-250 d	NA	late summer, fall, winter, early spring	streambeds	intragravel 20 to 80 cm deep	G	Riverbed	**DO**< 3 mg/l lethal, optimum >7 **Temp** 0-17 C, Optimum 4-12 C
Juveniles (freshwater) 1-3	days-years	insect larvae and adults, zooplankton	year-round, depending on race	streams, sloughs, rivers	surface to several meters	varied	Pools, stream and river margins, woody debris	Extremely varied freshwater life history. **DO**< 2 mg/l lethal, optimum >7 **Temp** 0-22 C, Optimum 8-12 C
Juveniles (Estuary) 1-2	days-6-months	copepods, euphausiids, amphipods, juvenile fish	Spring, summer, fall	BCH, BAY	N, P	All bottom types	estuarine, littoral	Sea-type can be estuarine dependent **Temp** 2-22 C, Optimum 8-12 C **Salinity** 0-33 ppt
Juvenile (marine) 1-2	6-9 months: Up to first marine annulus	epipelagic fish, euphasiids, large copepods, pelagic amphipods	Spring-Winter	IP, ICS, MCS, OCS, USP, BSN	P	All bottom types	UP, F, G, CL, E	Initially surface oriented; some stocks move rapidly offshore, some remain nearshore. **Temp:** 1-15 C, Optimum 5-12 C

Immature and Maturing Adults (marine) 1-2	2-8 years of age	epipelagic fish (herring, sand lance, smelt, anchovy), shrimp, squid	Year Round	BAY, IP, ICS, MCS, OCS, USP, BSN	N, P	All bottom types	UP, F, G, CL, E	Not surface oriented until maturing. Use salinity gradients, olfaction for terminal homing. **Temp:** 5-22 C
Adults (freshwater) 1-3	2 weeks-4 months	little or none	Spawning: (July-Feb) Freshwater Migration: Year round, varies greatly among populations	Rivers, large streams and tributaries	0.5-10 m	Alluvial bottom types; G for spawning	Deep pools for resting, Riffles, pool-riffle transition for spawning	Entry timing to freshwater highly variable. **Temp:** 1-26 C, Optimum 4-15 C

Abbreviations used in table: U = Unknown; NA = not applicable.
EFH Level: 0) No systematic sampling has been conducted for this species and life stage; may have been caught opportunistically in small numbers during other surveys; 1) Presence/absence distribution data are available for some or all portions of the geographic range; 2) Habitat-related densities are available; 3) Habitat-related growth, reproduction, or survival rates are available; 4) Habitat-related production rates are available.
Location where found (in waters of these depths): BCH = beach (intertidal); ICS = inner continental shelf (1-50 m); MCS = middle continental shelf (50-100 m); OCS = outer continental shelf (100-200 m); USP = upper slope (200-1000 m); LSP = lower slope (1000-3000 m); BSN = basin (>3000 m); BAY = nearshore bays, depth if appropriate (e.g., fjords); IP = island passes (areas of high current), depth if appropriate.
Where found in water column: D = demersal (found on bottom); SD/SP = semi-demersal or semi-pelagic if slightly greater or less than 50% on or off bottom; P = pelagic (found off bottom, not necessarily associated with a particular bottom type); N = neustonic (found near surface).
Bottom Types: M = mud; S = sand; R = rock; SM = sandy mud; CB = cobble; C = coral; MS = muddy sand; G = gravel; K = kelp; SAV = subaquatic vegetation (e.g., eelgrass, not kelp).
Oceanographic Features: UP = upwelling; G = gyres; F = fronts; CL = thermo- or pycnocline; E = edges.

See table of contents for the following figures:

Figure 1. Map of the North Pacific Ocean and Bering Sea, showing the distribution of chinook spawning populations (stippled) and some of the landmarks referred to in the text. The distribution of chinook spawning populations north and east of Kotzebue Sound on the North American coast is unconfirmed (shown as question marks), except for a positive identification in the Mackenzie drainage.

Figure 2. Map of the North Pacific Ocean with histograms showing the catch (hundreds of thousands of fish) of chinook in major coastal fisheries from 1962-70. (Adapted from Major et al. 1978).

Figure 3. Marine EFH for chinook salmon general distribution and areas of known concentration of immature and maturing chinook to the limits of the US EEZ off Alaska. Areas of know n concentration are based on fishery closures to reduce bycatch of chinook salmon in the trawl fishery in the Bering Sea and in the Southeast Alaska troll fishery during chinook non-retention periods. Westward areas within the US EEZ not shown on the map are also EFH for chinook salmon.

Habitat Description for Coho (Silver) Salmon
(Oncorhynchus kisutch)

Management Plan and Area(s)   Salmon Fisheries in the EEZ off the Coast of Alaska, NPFMC, 1990

General Distribution and Life History

Coho salmon are widely distributed in cool areas of the North Pacific Ocean and most adjoining fresh and estuarine waters. Coho use more diverse habitats than other anadromous salmonids. They spawn in most accessible freshwater streams throughout their range, rear for at least 1 year in fresh or estuarine waters, and spend about 18 months at sea before reaching maturity. In North America, coho range along the Pacific coast from Monterey Bay, California, to Point Hope, Alaska, through the Aleutians (Figure 1). The species is most abundant in coastal areas from central Oregon north through southeast Alaska. In the southern part of their range, coho stocks are generally depressed from historical levels, and hatcheries are often used to supplement wild runs. The Central California Coast Evolutionary Significant Unit (ESU) and the Southern Oregon/Northern California Coast ESU are listed as threatened species under the Endangered Species Act. Coho are cultured for market in several countries; attempts to establish self-sustaining coho runs in other areas of the world have had limited success.

In the NMFS Alaska Region, most coho are wild fish with a distribution north to Point Hope on the eastern Chukchi Sea, west and south to the limits of U.S. territorial waters, and east to the Canadian border as far north as the Yukon River drainage. Coho catch in the Alaska Region is at historically high levels, and trends in abundance of most stocks are rated as stable.

Fishery

Important commercial, sport, and subsistence fisheries for coho occur from the Soviet Far East through the Bering Sea and along the west coast of North America as far south as central California. Trolling, gill nets, and purse seines are the primary commercial gear types. Gill nets, dip nets, rod and reel, traps, fish wheels, long lines, and snagging gear are used to harvest coho for subsistence and personal use. Subsistence fisheries are often cultural or traditional and take precedence over other fisheries. Personal use fisheries require a sport fishing license or exemption. Both subsistence and personal use fisheries are restricted to designated locations and specified bag limits. Sport catches of coho are taken by hook and line and snagging.

Most coho from the Alaska Region recruit to fisheries after 1 to 2 years in fresh water and about 16 months at sea. Fisheries in the Alaska Region primarily target adult coho and take place in coastal marine migration corridors, near the mouths of rivers and streams, and in freshwater migration areas. Those fisheries coincide with migrations toward spawning areas from July through October. A few areas are stocked annually with juvenile coho to provide put-and-take sport fishing.

Bycatch depends on gear type, but is usually limited to other salmon species. Chinook salmon bycatch is limited by regulation or treaty in most coho fisheries, but other salmon species are often targeted as part of the fishery. Species such as steelhead, Dolly Varden, pollock, Pacific cod, halibut, salmon sharks, and coastal rockfish make up a small part of the catch.

Relevant Trophic Information

Adult coho provide important food for bald eagles, terrestrial mammals (e.g., brown bear, black bear, and river otter), marine mammals (e.g., Steller sea lion, harbor seal, beluga, and orca), and salmon sharks. Adults also transfer essential nutrients from marine to freshwater environments. Juveniles are eaten by a variety of birds (e.g., gulls, terns, kingfishers, cormorants, mergansers, herons), fish (e.g., Dolly Varden, steelhead, cutthroat trout, and arctic char), and mammals (e.g., mink and water shrew). Juvenile coho are also significant predators of pink salmon fry during their seaward migration.

Potential Gear Impacts on the Habitats of this or Other Species

Directed fisheries on coho salmon in Alaska include marine commercial and recreational hook-and-line fisheries; marine commercial gill-net and seine fisheries; and estuarine and riverine gill-net (both set-net and drift), recreational, personal use, and subsistence fisheries. Two types of impacts can occur: (1) direct effects of the fishing gear on habitat; and (2) bycatch or entanglement of non-target species. In the marine fisheries, direct impact of the gear on marine habitats is limited, but some localized effects can occur, such as trolling weights damaging coral or purse seines damaging kelp beds or benthic structure. Bycatch and entanglement of non-target species can occur in the marine fisheries, such as bycatch of demersal rockfish in hook-and-line fisheries, and entanglement of seabirds and marine mammals in net fisheries. In the estuarine and riverine fisheries, direct impacts on riparian vegetation and channel morphology can occur from fishing activities, such as damage to the stream bank from boat wakes and removal of woody debris to provide access. Trampling of stream banks and the stream channel can also damage coho habitat. Where use levels are high, this type of impact may require restoration or management initiatives. An example is the Kenai River where restoration work was needed to repair damage from recreational fishing for chinook salmon and other salmonids.

Approximate Upper Size Limit of Juvenile Fish (in cm) 35 cm

Sources for Additional Distribution Data

Adults: ADF&G, Commercial Fisheries Management and Development Division, 907-465-4160; ADF&G, Sport Fish Division, 907-465-4180; ADF&G, Subsistence Division, 907-465-4147;

Juveniles: ADF&G, Habitat and Restoration Division, 907-465-4105; USFS, Region 10 Office of Wildlife, Fish Ecology, and Watershed, 907-586-8752; NMFS, Alaska Fisheries Science Center, Auke Bay Laboratory, Mike Murphy, 907-789-6036.

The known distribution of adults and juveniles is given in the current ADF&G *Atlas to the Catalogue of Waters Important for Spawning, Rearing, or Migration of Anadromous Fishes*. The Catalogue and Atlas are divided into six volumes corresponding to the State's six resource management regions (Arctic, Interior, Western, Southwest, Southcentral, and Southeast). The principal contact for the ADF&G catalogue/atlas project is Ed Weiss, ADF&G Regional Office in Anchorage (907-267-2305). Copies of the entire Atlas and Catalogue are available for inspection at the ADF&G Habitat and Restoration Division Regional Offices in Fairbanks and Anchorage and the Headquarters Office in Juneau. Copies of a regional volume of the Atlas are available for inspection at ADF&G offices in Ketchikan, Wrangell, Petersburg, Sitka, Haines, Yakutat, Palmer, Cordova, Glennallen, Soldotna, Homer, Kodiak, Sand Point, King Salmon, Dillingham, Bethel, Delta Junction, Tok, Nome, and Dutch Harbor.

Habitat and Biological Associations

Juvenile and adult coho are highly migratory and depend on suitable habitat in their migration routes. Unobstructed passage and suitable water depth, water velocity, water quality, and cover are important elements in all migration habitat. Soon after emergence in spring, fry may move around considerably seeking optimal, unoccupied habitat for rearing. In fall, juveniles may migrate from summer rearing areas to areas with winter habitat. Such juvenile migrations may be extensive within the natal stream basin or between basins through salt water or connecting estuaries. Seaward migration of coho smolts occurs usually after 1-2 years in fresh water. The migration is timed primarily by photoperiod and occurs in spring, usually coincident with a spring freshet. During this transition, coho undergo major physiological changes to enable them to osmoregulate in salt water and are at that time, especially sensitive to environmental stress. At sea, juvenile Alaska coho generally migrate north and offshore into the North Pacific Ocean and Bering Sea. After 12 to 14 months at sea, they migrate to coastal areas and then along the coast to their natal streams.

Egg/Larvae: Fertilized eggs and larvae require incubation in porous substrate that allows constant circulation of cool, high-quality water that provides oxygen and removes waste. Interstitial space in the substrate must be great enough to allow growth and movement through the gravel to accommodate emergence. Sand or silt in the substrate can limit intragravel flow and trap emerging fry. As the yolk sac is absorbed, the larvae become photopositive and move through the substrate into the water column. Fry emerge between March and July, depending on when the eggs were fertilized and water temperature during development.

Juveniles (Fresh Water): In Alaska, juvenile coho usually spend 1-2 years in fresh or estuarine waters before migrating to sea, although they may spend up to 5 years where growth is slow. Coho need to attain a length of about 85 mm to become smolts. Coho smolt production is most often limited by the productivity of freshwater and estuarine habitats used for juvenile rearing. Survival from eggs to smolts is usually less than 2%. If spawning escapement is adequate, sufficient fry are usually produced to exceed the carrying capacity of rearing habitat. In this case, carrying capacity of summer habitat sets a density-dependent limit on the juvenile population. This summer population is then reduced by density-independent mortality over winter depending on the severity of winter conditions, fish size, and quality of winter habitat.

Coastal streams, lakes, estuaries, and tributaries to large rivers can all provide coho rearing habitat. The most productive habitats are in smaller streams less than fourth order having low-gradient alluvial channels with abundant pools often formed by large woody debris or fluvial processes. Beaver ponds can provide some of the best summer rearing areas for juvenile coho. Coho juveniles also may use brackish-water estuarine areas in summer and migrate upstream to fresh water to overwinter.

During the summer rearing stage, fish density tends to be highest in areas with abundant food (drifting aquatic invertebrates and terrestrial insects that fall into the water) and structural habitat elements (e.g., large woody debris and associated pools). Preferred habitats include a mixture of different types of pools, glides, and riffles with large woody debris, undercut banks, and overhanging vegetation which provide advantageous positions for feeding. Coho grow best where water temperature is between 10 and 15°C, and dissolved oxygen (DO) is near saturation. Juvenile coho can tolerate temperatures between 0° and 26°C if changes are not abrupt. Their growth and stamina decline significantly when DO levels drop below 4 mg/l, and a sustained concentration less that 2 mg/l is lethal. Summer populations are usually constrained by density- dependant effects mediated through territorial behavior. In flowing water, juvenile coho usually establish individual feeding territories, whereas in lakes, large pools, and estuaries they are less likely to establish territories and may aggregate where food is abundant. Growth in summer is often density-dependent, and the size of juveniles in late summer is often inversely related to population density.

In winter, food is less important and territorial behavior fades. Juveniles aggregate in freshwater habitats that provide cover with relatively stable temperature, depth, velocity, and water quality. Winter mortality factors include hazardous conditions during winter peak stream flow, stranding of fish by ice damming, physiological stress from low temperature, and progressive starvation. In winter, juveniles prefer a narrower range of habitats than in summer, especially large mainstream pools, backwaters, and secondary channel pools with abundant large woody debris, and undercut banks and debris along riffle margins. Survival in winter, in contrast to summer, is generally not density-dependent, and varies directly with fish size and amount of cover and ponded water, and inversely with the magnitude of the peak stream flow.

The seaward migration of smolts in native stocks is typically in May and June, and is presumably timed so that the smolts arrive in the estuary when food is plentiful. Habitat requirements during seaward migration are similar to those of rearing juveniles, except that smolts tend to be more fragile and more susceptible to predation. High streamflow aids their migration by assisting them downstream and reducing their vulnerability to predators. Turbidity from melting glaciers may also provide cover from predators. Migration cover is also provided by woody debris and submerged riparian vegetation. Migrating smolts are particularly vulnerable to predation because they are concentrated and moving through areas of reduced cover where predators congregate. Mortality during seaward migration can exceed 50%.

Juveniles (Estuarine): Juvenile coho primarily use estuarine habitat during their first summer and also as they are leaving fresh water during their seaward migration. Intertidal sections of freshwater streams (i.e., stream-estuary ecotones) can be important rearing habitat for age-0 coho from May to October. These areas may account for one-quarter of the juvenile production in small streams. Growth in these areas is particularly rapid because of abundant invertebrate food. Habitats used include glides and pools during low tide, and coho occupy the freshwater lens during high tide. In fall, juvenile coho move upstream to fresh water to overwinter.

During seaward migration, coho smolts may be present in the estuary from May to August. Rapid growth during the early period in the estuary is critical to survival because of high size-dependent mortality from predation.

Juveniles (Marine): After leaving fresh water, coho in the Alaska Region spend up to 4 months in coastal waters before migrating offshore and dispersing throughout the North Pacific Ocean and Bering Sea. Southeast Alaska juvenile coho are ubiquitous in inside waters from June to August at depths up to 50 m, and move offshore by September. Offshore, juvenile salmon are concentrated over the continental shelf within 37 km of shore where the shelf is narrow, but may extend to at least 74 km from shore in some areas. Stock-specific aggregations have not been noted at this stage. Marine invertebrates are the primary food when coho first enter salt water, and fish prey increase in importance as the coho grow.

Immature and Maturing Adults (Marine): Most coho occupy epipelagic areas in the central Gulf of Alaska and Bering Sea during the 12 to 14 months after leaving coastal areas. Some coho also use coastal and inshore waters at this life stage, but those are likely to be smaller at maturity. The spatial distribution of suitable habitat conditions is affected by annual and seasonal changes in oceanographic conditions; however, coho generally use offshore areas of the North Pacific Ocean and the Bering Sea from 40 to 60° north latitude (Figure 2). The distribution of ocean harvest is generally more northerly than that for stocks from other regions (Figure 3).

Growth is the objective at this stage of the coho life cycle, and bioenergetics are controlled mainly by food quantity, food quality, and temperature. Food for salmon is most abundant above the halocline which may range from 100 to 200 meters in depth in the North Pacific. The bioenergetics of growth is best in epipelagic offshore habitat where forage is abundant and sea surface temperature is between 12 and 15°C. Coho rarely use areas where sea surface temperature exceeds 15°C.

Most coho remain at sea for about 16 months before returning to coastal areas and entering fresh water to spawn, although some precocious males will return to spawn after about 6 months at sea. Before entering fresh water to spawn, most coho slow their feeding and begin to lose weight as they develop secondary sex characteristics. Survival from smolt to adult averages about 10 percent.

Adults (Freshwater): Adult coho enter fresh water from early July through December and spawn from September through January. Fidelity to natal streams is high and straying rates are generally less than 5 percent. The fish feed little and migrate upstream using olfactory cues that were imprinted in early development.

Adult coho may travel for a short time and distance upstream to spawn in small streams or may enter large river systems and travel for weeks to reach spawning areas more than 2,000 km upstream. Upstream migrations are blocked where fall heights exceed 3.3 m or falls more than 1.2 m high have jumping pools less than 1.25 times the falls height. Blockages also occur where stream gradient exceeds 12 percent for more than 70 m, or 16 percent for more than 30 m, or 20 percent for more than 15 m, or 24 percent for more than 8 m.

Spawning sites selected for use have relatively silt-free gravels ranging from 2 mm to 10 cm in diameter, well-oxygenated intragravel flow, and nearby cover. In Alaska streams, between 2,500 and 4,000 eggs are deposited among several nests by each female coho. Several males may attend each female, but larger males usually dominate by driving off smaller males. Soon after spawning, adult coho die in or near the spawning areas.

References

Baker, T. T., A.C. Wertheimer, R. D. Burkett, R. Dunlap, D.M. Eggers, E. L. Fritts, A. J. Gharrett, R.A. Holmes, and R. L. Wilmot. 1996. Status of Pacific salmon and steelhead escapements in Southeastern Alaska. Fisheries 21(10): 6-18.

Bjornn, T. C. and D. W. Reiser. 1991. Habitat requirements of salmonids in streams. *In*: W.R. Meehan, ed. Influences of forest and rangeland management on salmonid fishes and their habitats. AFS Special Publication 19:83-138.

Burger, C. V. and A. C. Wertheimer. 1995. Pacific salmon in Alaska. Pages 343-347 *In*: E.T. LaRoe, G. S. Farris, C.E. Puckett, P.D. Doran, and M. J. Mac, eds. Our living resources: a report to the Nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S.D.I., NBS, Washington, D.C.

Burgner, R.L. 1980. Some features of ocean migrations and timing of Pacific salmon. Pages 153-164 *in*: W.J. McNeil and D.C. Himsworth, eds. Salmonid ecosystems of the North Pacific. OSU Press. Corvallis, Oregon.

Crone, R.A. and C.E. Bond. 1976. Life history of coho salmon, *Oncorhynchus kisutch*, in Sashin Creek, Southeastern Alaska. Fishery Bulletin 74(4):897-923.

Elliott, S. 1994. Coho salmon. Alaska Department of Fish and Game Wildlife Notebook Series. Alaska Dept. of Fish and Game, Juneau. 2 p.

Elliott, S.T., A.E. Schmidt, and D.A Sterritt. 1989. A study of coho salmon in southeast Alaska. Fishery Data Series No. 113, Alaska Dep. Fish and Game, Div. Sport Fish, Juneau.

Elliott, S.T., and D.A Sterritt. 1990. A study of coho salmon in southeast Alaska, 1989: Chilkoot Lake, Yehring Creek, Auke Lake, and Vallenar Creek. Fishery Data Series No. 90-53, Alaska Dep. Fish and Game, Div. Sport Fish, Anchorage.

Fraidenburg, M.E., M.A. Hunter, A.J. M. Stohr, and P.L. Pattillo. 1985. The ocean journeys of Pacific Northwest chinooks and cohos, and steelheads, pages 109-126 *In* R.H, Stroud, ed., Proceedings of the tenth annual marine recreational fisheries symposium. National Coalition for Marine Conservation, Inc., Savannah, GA.

Geiger, H.J., and B. Frennette, eds. 1997. Run forecasts and harvest projections for 1997 Alaska salmon fisheries and review of the 1996 season: the short version. Alaska Dept. of Fish and Game, Regional Information Report No. 5197-01. 9 p.

Gray, P.L., J.F. Koerner, R.A. Marriott. 1981. The age structure and length-weight relationship of southeastern Alaska coho salmon (*Oncorhynchus kisutch*, 1969-1970. Alaska Department of Fish and Game, Div. Commercial Fisheries, Southeastern Alaska Coho Research, Juneau, AK.

Halupka, L.C., M.D. Bryant, M.F. Willson, J.K. Troyer, and F.H. Everest. 1996. Coho salmon (*Oncorhynchus kisutch*). Chapter 6 *In*: Biological characteristics and population status of anadromous salmon in Southeast Alaska. USDA Forestry Sciences Laboratory 2770 Sherwood Lane, Suite 2A, Juneau, AK 99801-8545.

Hasler, T.J. 1987. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) -- coho salmon. U.S. Fish and Wildlife Serv. Biol. Rep. 82(11.70). U.S. Army Corps of Engineers, TR EL-82-4.

Laufle, J.C., G.B. Pauley, and M.F. Shepard. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) -- coho salmon. U.S. Fish and Wildlife Service Biological Report 82(11.48). U.S. Army Corps of Engineers, TR EL-82-4. 18 pp.

Lorenz, J.M., M.L. Murphy, J.F. Thedinga, and K.V. Koski. 1991. Distribution and abundance of juvenile salmon in two main channel habitats of the Taku River, Alaska and British Columbia. NOAA Tech. Memo. NMFS F/NWC-206.

Manzer, J.I., T. Ishida, A.E. Peterson, and M.G. Hanavan. 1965. Salmon of the North Pacific Ocean. Part V. Offshore distribution of salmon. Int. North Pac. Fish. Comm. Bull. 15:452 pp.

McMahon, T.E. 1983. Habitat suitability index models: coho salmon. U.S. Dept. Of the Interior, Fish and Wildlife Service. FWS/OBS-82/10.49. 29 pp.

Meehan, W.R. and T.C. Bjornn. 1991. Salmonid distributions and life histories. Pages 47-82 *in*: W.R. Meehan, ed. Influences of forest and rangeland management on salmonid fishes and their habitats. AFS Special Publication 19.

Murphy, J. 1995. Patterns in the spatial distribution of salmon *(Oncorhynchus* spp.) captured in the Pacific driftnet fishery for flying squid (*Ommastrephes bartrami*). M.S. Thesis. Univ. Of Alaska, Fairbanks. 110 p.

Murphy, M.L., K.V. Koski J. M. Lorenz, and J. F. Thedinga. In press. Downstream migrations of juvenile Pacific salmon (*Oncorhynchus* sp.) in a glacial transboundary river. Can. J. Fish. Aquat. Sci.

Murphy, M.L., J. Heifetz, J.F. Thedinga, S.W. Johnson, and K.V. Koski. 1989. Habitat utilization by juvenile Pacific salmon (*Oncorhynchus*) in the glacial Taku River, southeast Alaska. Can. J. Fish. Aquat. Sci. 46:1677-1685.

Murphy, M.L., J.F. Thedinga, K.V. Koski, and G.B. Grette. 1984. A stream ecosystem in an old-growth forest in Southeast Alaska. Part V: Seasonal changes in habitat utilization by juvenile salmonids, p. 89-98. In W.R. Meehan, T.R. Merrell, Jr., and T.A. Hanley [eds.] Fish and wildlife relationships in old-growth forests: proceedings of a symposium. Am. Inst. Fish. Res. Biol.

Myers, K. W., K. Y. Aydin, R. V. Walker, S. Fowler, and M. L. Dahlberg. 1996. Known ocean ranges of stocks of Pacific salmon and steelhead as shown by tagging experiments, 1956-1995. (NPAFC Doc. 192.) FRI-UW-9614. University of Washington, Fisheries Research Institute, Box 357980, Seattle, WA 98195-7980.

Nickleson, T.E. and J.A. Lichatowich. The influence of the marine environment on the interannual variation in coho salmon abundance. Pages 24-36 *in*: W.G. Pearcy, ed. The influence of ocean conditions on the production of salmonids in the North Pacific. OSU Sea Grant Publication ORESU-W-83-001.

Olsen, J.C. 1994. Alaska salmon resources. Pages 77-89 *in* L. Low, J. Olsen, and H. Braham, eds. Status of living marine resources off Alaska. 1993. NOAA Tech. Memo. NMFS-AFSC-27. U.S.D.C. Alaska Fisheries Science Center, Seattle.

Orsi, J.A., A.G. Celewycz, D. G. Mortensen, and K. A. Herndon. 1987. Sampling juvenile chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*) by small trolling gear in the northern and central regions of southeastern Alaska, 1985. NOAA Technical Memorandum NMFS F/NWC-115.

Orsi, J. A., J. M. Murphy, and A. L. J. Brase. 1997. Survey of juvenile salmon in the marine waters of southeastern Alaska, May-August 1997. (NPAFC Doc. 277).

Slaney, T.L., K.D. Hyatt, T.G. Northcote, and R.J. Fielden. Status of anadromous salmon and trout in British Columbia and Yukon. Fisheries 21(10): 20-35.

Sandercock, F.K. 1991. Life history of coho salmon. Pages 395-445 *in*: C. Groot and L. Margolis, eds. Pacific salmon life histories. UBC Press, Vancouver, BC.

Thedinga, J.F., M.L. Murphy, S.W. Johnson, J.M. Lorenz, and K.V. Koski. 1994. Determination of salmonid smolt yield with rotary-screw traps in the Situk River, Alaska, to predict effects of glacial flooding. N. Am. J. Fish. Manage. 14:837-851.

Wertheimer, A.C. Status of Alaska salmon. 1997. Pages 179-197 *in*: D.J. Stouder, P.A. Bisson, and R.J. Naiman, eds. Pacific salmon and their ecosystems: status and future options. Chapman and Hall, Inc., New York.

SPECIES: Coho Salmon

Stage -EFH Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic/ Riverine Features	Other
Eggs/Larvae EFH Level: 1-3	150 days at optimum temperature	NA	Fall/winter	WC, LK	Intra-gravel	G	Streambed	DO < 2 mg/l lethal, optimum >8 mg/l; Temperature 0-17°C; optimum 4.4-13.3°C; substrate 2-10 cm with <15% fines (<3.3 mm), optimum <5% fines
Juveniles, Fresh water (fry to smolt) EFH Level: 1-4	1-5 yrs, most (>90%) 1-2 yrs	invertebrates and fish	Entire year	WC, LK	Entire column	N/A	Pools, woody debris, currents for migration	DO lethal at <3 mg/l, optimum at saturation; Temperature 0-26°C; optimum 12-14°C.
Juveniles, Estuarine EFH Level: 1-2	1-6 months	Invertebrates and fish	Rearing - summer, Migration - spring	EST	Mid-water and surface, P, N	N/A	Pools, glides, etc.	
Juveniles, Marine EFH Level: 0-1	up to 4 months	fish and invertebrates	June - September	BCH, ICS, MCS, BA, IP	P, N	N/A	UP, CL	Temperature <15°C; Depth <10 m
Immature/ Maturing Adults, Marine EFH Level: 1-2	12-14 months	Fish (e.g., herring, sand lance)		BCH, ICS, MCS, OCS, USP, LSP, BSN, BAY, IP	P, N	N/A	U	Temperature range 1-26°C; optimum 12-14°C
Adults, Fresh water EFH Level: 1-3	up to 2 months	little or none	migration - fall; spawning - fall, winter	WC, LK	Deep parts of streams and lakes	Alluvial bottom types	Deep pools, Pool-riffle transition	Temperature range 1-26°C; optimum 12-14°C

Abbreviations used in table:
EFH Level: Range indicates levels in different regions of Alaska: 0) No systematic sampling has been conducted for this species and life stage; may have been caught opportunistically in small numbers during other surveys; 1) Presence/absence distribution data are available for some or all portions of the geographic range; 2) Habitat-related densities are available; 3) Habitat-related growth, reproduction, or survival rates are available; 4) Habitat-related production rates are available.
Location: WC = water courses, rivers, streams, sloughs; LK = lakes, ponds (some are temporary); BCH = beach (intertidal); EST = estuarine, intermediate salinity, nearshore bays with inlet watercourses, eelgrass and kelp beds; ICS = inner continental shelf (1-50 m deep); MCS = middle continental shelf (1-100 m deep); OCS = outer continental shelf (1-200 m); BAY = nearshore bays (e.g., fjords); IP = island passes (areas of high current).
Water Column: P = pelagic (found off bottom, not necessarily associated with a particular bottom type); N = neustonic (found near surface).
Bottom Type: G = gravel; K = kelp; SAV = subaquatic vegetation (e.g., eelgrass).
Oceanographic/Riverine Features: UP = upwelling; G = gyres; F = fronts; CL = thermo- or pycnocline; E = edges. General: U = Unknown; NA = not applicable

See table of contents for the following figures:

Figure 1. Coastal and spawning distribution of coho salmon (Sandercock 1991).

Figure 2. Occurrence of coho salmon in the North Pacific Ocean, May through August (from Manzer et al. 1965).

ALASKA SALMON EFH PRIORITY RESEARCH NEEDS

The Alaska EFH Core Team has developed a draft framework for evaluating research and management priorities. The framework is intended to categorize activities into a logical progression toward the goal of conserving or restoring EFH. By evaluating current knowledge levels and status of EFH, priority research and management activities can be identified for the various FMPs.

In applying the framework to salmon, research priorities are focused on two activities:(1) acquiring basic data on salmon distribution and life history for regions where these data are missing; and (2) acquiring knowledge and developing management tools for use in conserving or restoring habitat areas of particular concern (identified above). Based on the draft framework, the following research needs are considered to be the highest priorities:

- Increase the scope of survey data for presence/absence, habitat-specific utilizations, in areas where intensive development, current or planned, threatens salmon habitat.

- Digitize species distribution and life-history information in anadromous stream atlas for inclusion in SASpop GIS system. A one-time effort would allow efficient use of existing information for definition of EFH.

- Research into the habitat values for salmon of the identified Habitat Areas of Particular Concern. These include nearshore marine and estuarine areas with submerged or emergent aquatic vegetation and freshwater streams and lakes in areas under intensive development for urban, industrial, timber harvest, and other land uses.